Figure 4-2. Streams, rivers, and lakes with documented salmon use overlain with the Pebble 2020 Mine Plan. Anadromous streams lost are the streams identified as lost in the FEIS and are listed in Table 4-1 (USACE 2022). Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

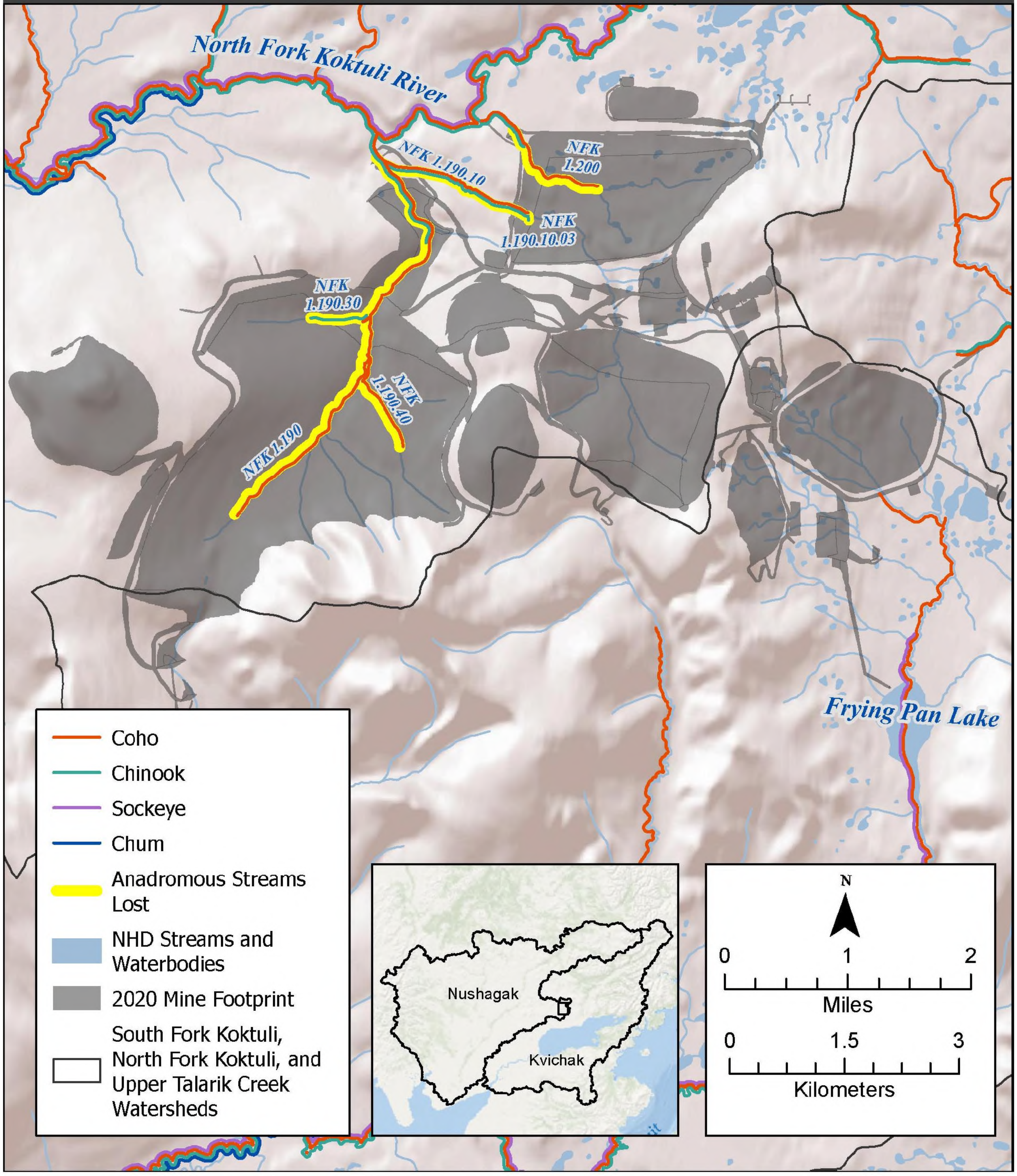

Table 4-1. Length of anadromous fish streams permanently lost in tributaries to the North Fork Koktuli River associated with the 2020 Mine Plan.

Tributary	AWC Code [a]	Length of Anadromous Habitat (miles) [b]
NFK 1.190	325-30-10100-2202-3080-4083-5215	4.2
NFK 1.190.10	325-30-10100-2202-3080-4083-5215-6001	1.7
NFK 1.190.10.03	325-30-10100-2202-3080-4083-5215-6001-7012	0.05
NFK 1.190.30	325-30-10100-2202-3080-4083-5215-6006	0.5
NFK 1.190.40	325-30-10100-2202-3080-4083-5215-6007	0.9
NFK 1.200	325-30-10100-2202-3080-4083-5217	1.1
TOTAL		8.5

Notes:
[a] Source = Giefer and Graziano 2022.
[b] Source = USACE 2022.

The discharge of dredged or fill material from the 2020 Mine Plan would result in the permanent loss of at least 7.1 miles (11.4 km) of Coho Salmon habitat and at least 3.7 miles (6.0 km) of Chinook Salmon habitat (Table 4-2) (Giefer and Graziano 2022).[58] Most of these losses would occur where the bulk TSF would be built (Figure 4-1) (USACE 2020a: Section 4.24). Construction of the bulk TSF alone would permanently eliminate 5.6 miles (9.1 km) of anadromous fish streams in Tributaries NFK 1.190, NFK 1.190.30, and NFK 1.190.40 (USACE 2022). These three anadromous fish streams provide at least 4.8 miles (7.7 km) of rearing habitat and 3.7 miles (6.0 km) of spawning habitat for Coho Salmon and at least 1.4 miles (3.4 km) of rearing habitat and 0.8 mile (1.3 km) of migrating habitat for Chinook Salmon (Giefer and Graziano 2022). Construction of other mine site components, including the main WMP (Figure 4-1), would result in the remaining documented anadromous fish stream losses in Tributaries NFK 1.190.10, NFK 1.190.10.03, and NFK 1.200 (Figure 4-2).

Table 4-2. Coho and Chinook salmon stream habitat permanently lost in the North Fork Koktuli River watershed associated with the 2020 Mine Plan. From Giefer and Graziano (2022).

	Length of Anadromous Habitat (miles)			
Species	Rearing	Spawning	Present	TOTAL [a]
Coho Salmon	7.1	3.7	-	7.1
Chinook Salmon	2.3	-	1.4	3.7

Notes:
[a] Coho and Chinook salmon habitat overlap, and rearing and spawning habitat overlap, so individual values cannot be added together. The totals represent the total extent of habitat lost for each species of Coho and Chinook salmon.

Tributary NFK 1.190 and its sub-tributaries have been documented to provide Coho Salmon spawning habitat, and rearing juvenile salmon have been observed in Tributaries NFK 1.190 and NFK 1.200 (USACE 2020a: Section 4.24). Rearing juvenile Chinook Salmon have been documented to occur in Tributary NFK 1.200 (USACE 2020a: Section 4.24). Chinook Salmon rear in the third-order

[58] Coho Salmon are documented to occur in 7.1 miles (11.4 km) of the 8.5 miles (13.7 km) of anadromous fish streams that would be lost, and Chinook Salmon are documented to occur in 3.7 miles (6.0 km) of the 8.5 miles (13.7 km) of anadromous fish streams that would be lost (Table 4.2).

beaver-modified stream that the bulk TSF would eliminate (i.e., Tributary NFK 1.190), along with 0.5 mile (0.8 km) of Tributary NFK 1.190.30 (Figure 4-2) (Giefer and Graziano 2022).[59]

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles (13.7 km) of anadromous fish streams that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8).

4.2.1.2 Adverse Effects from Permanent Loss of Anadromous Fish Streams at the Mine Site

The 8.5 miles (13.7 km) of permanent anadromous fish stream losses would result in fish displacement, injury, and mortality. In addition to the permanent removal of streamflow and subsequent effects on fish migration, "fisheries, invertebrate, and riparian habitat and productivity would be permanently removed" from lost streams (USACE 2020a: Pages 4.24-3 and 4.24-4). The permanent loss of 8.5 miles (13.7 km) of anadromous fish streams from a single project represents a large impact—one that is unprecedented in the context of the CWA Section 404 regulatory program in Alaska—and as discussed, would result in long-term adverse effects on salmon populations in the NFK watershed.

All 8.5 miles (13.7 km) of anadromous fish streams would be completely eliminated and, thus, would permanently lose the ability to support salmon. Coho Salmon would lose at least 7.1 miles (11.4 km) of habitat as a direct result of discharges of dredged or fill material associated with the 2020 Mine Plan, which amounts to more than 11 percent of documented Coho Salmon habitat in the NFK watershed (Table 3-6). Habitat losses for Chinook Salmon would be 8.7 percent of documented habitat in the NFK watershed.

The anadromous fish streams that would be permanently lost as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan are ecologically valuable, particularly for juvenile salmon (Section 3.2.4). Tributary NFK 1.190 is connected with ponds and seasonally to permanently inundated wetlands that result from beaver activity (USFWS 2021).[60] These features provide excellent rearing habitat and important overwintering and flow velocity refugia for salmonids (Section 3.2.4) (Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Lang et al. 2006). The permanent loss of anadromous fish streams resulting from the discharges of dredged or fill material associated with the 2020 Mine Plan would also result in the loss of salmon spawning habitat, which would, in turn, result in the loss of marine-derived nutrients those fishes would have contributed upon death. Given the naturally low nutrient concentrations in these streams, the inputs of marine-derived nutrients may be

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[59] Fish surveys have documented juvenile Coho Salmon in a short (260-foot) reach at the downstream end of this tributary, NFK 1.190.30 (Giefer and Graziano 2022).

[60] Connection to such floodplain wetland and pond habitats can greatly enhance the carrying capacity and productive potential of anadromous fish streams (Section 3).

especially important in supporting primary and secondary production and, thus, food for juvenile salmonids in these and downstream habitats (Section 3.3.4). These streams also support biological production via inputs of leaf litter from deciduous shrubs and grasses in riparian areas (Meyer et al. 2007, Dekar et al. 2012), which help fuel the production of macroinvertebrates, a key food for salmonids (Table 3-3). Thus, the anadromous fish streams that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan, as well as similar habitats in the SFK, NFK, and UTC watersheds, play an essential role in the successful completion of the life cycle of salmon.

These anadromous fish stream losses alone would be unacceptable, but the effects of these losses would be compounded by the fact that such losses would affect Coho and Chinook salmon populations that are uniquely adapted to the physical and chemical conditions of their natal streams (i.e., their streams of birth, see Section 3.3.1). Adaptation to local environmental conditions results in discrete, genetically distinct salmonid populations. This biocomplexity—operating across a continuum of integrated, nested spatial and temporal scales—depends on the abundance and diversity of aquatic habitats in the area and acts to stabilize overall salmon production and fishery resources (Section 3.3.3) (Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019). As discussed below, the substantial spatial and temporal extent of anadromous fish stream losses resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan suggests that these losses would reduce the overall reproductive capacity and productivity of Coho and Chinook salmon in the entire NFK watershed.

Pacific salmon exhibit high fidelity to their natal spawning and rearing environments, which results in genetic variation among discrete populations (Quinn 2018). The existence of discrete, genetically distinct salmon populations has been well-documented in the Bristol Bay watershed (Olsen et al. 2003, Ramstad et al. 2010, Quinn et al. 2012, Dann et al. 2012, Shedd et al. 2016, Brennan et al. 2019, Raborn and Link 2022). Both the Koktuli River (including the SFK and NFK) and UTC are known to support genetically distinct populations of Sockeye Salmon (Dann et al. 2012, Shedd et al. 2016, Dann et al. 2018). Research has shown that these distinct populations can occur at very fine geographic scales (Section 3.3.3). For example, Sockeye Salmon populations in close proximity to each other show phenotypic variations related to differences in spawning habitats (ecotypes) (Ramstad et al. 2010), and Sockeye Salmon that use spring-fed ponds and streams as close as approximately 0.6 mile (1 km) apart exhibit differences in traits (e.g., spawn timing and productivity) that suggest they may comprise discrete populations (Quinn et al. 2012).

Genetic baselines for salmonid species in Alaska are being updated or are under development, with some species being further along than others. Research on the presence of genetically distinct populations of Coho and Chinook salmon in Alaska is ongoing, and additional genetically distinct populations have been identified in recent years (Section 3.3.3.2). Existing evidence suggests that local adaptation and fine-scale population structure likely exist for these species as well (Olsen et al. 2003,

Sethi and Tanner 2014, Clark et al. 2015).[61] Similar patterns of genetic variation among species emphasize the vital importance that landscape heterogeneity (i.e., habitat complexity across the intact ecosystem) plays in determining genetic structure (Ackerman et al. 2013).

Coho and Chinook salmon are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations. As a result, these species may be more likely to be adversely affected by habitat losses that would occur as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan. Coho and Chinook salmon have the greatest number of population extinctions among the five species of Pacific salmon (Nehlsen et al. 1991, Augerot 2005). Many of the patterns of population extinction relate to longer periods of their life history spent rearing in freshwater, making them more vulnerable to freshwater habitat loss and degradation. For example, Chinook Salmon populations that rear for 1 or more years in freshwater—the dominant type in the Bristol Bay watershed (Healey 1991)—have a higher rate of extinction than populations that migrate to sea within their first year of life (Gustafson et al. 2007). The Nushagak River is the largest producer of Chinook Salmon in the Bristol Bay watershed. In October 2022, ADF&G recommended that Nushagak River Chinook Salmon be designated as a stock of management concern based on the inability of the stock to meet inriver run management goals during 5 of the past 6 years (ADF&G 2022f). This potential designation highlights the importance of the species in this region. During the upcoming March 2023 Board of Fish meeting, a decision on the development and implementation of an ADF&G management action plan to prevent further decline of the Nushagak River Chinook Salmon stock will be discussed. These conservation concerns surrounding the Nushagak River Chinook Salmon provide support for avoiding unacceptable adverse effects to this valuable species.

Alaska Coho Salmon populations are generally small, isolated, and likely exhibit local adaptation to different spawning and freshwater rearing habitats (Olsen et al. 2003). They occupy a wide array of freshwater habitat types, with many populations occupying small first- and second-order headwater streams with limited spawning and juvenile rearing habitat (Sandercock 1991, McCracken 2021). Small, genetically diverse populations of Coho Salmon represent reproductively isolated populations that are innately adapted to their spawning and rearing habitats (Dittman and Quinn 1996, Olsen et al. 2003, Peterson et al. 2014, Bett and Hinch 2016, McCracken 2021). The loss of these habitats would threaten the long-term fitness of these locally adapted populations (Olsen et al. 2003, Mobley et al. 2019). ADF&G has developed a genetic baseline for Coho Salmon for Cook Inlet, but genetic baselines have not been completed elsewhere in Alaska due to a lack of representative samples. In the Cook Inlet watersheds, the most genetically divergent populations are generally those farthest upstream and those from the most southern portion of Cook Inlet (Barclay and Habicht 2019).

[61] Advances in genomics and other techniques are allowing detection of genetic structure at increasingly fine scales; as methods to evaluate these genetic differences improve, researchers are uncovering more fine-scaled population structure in many salmon species (Meek et al. 2020).

Olsen et al. (2003) summarize the implications of Coho Salmon population structuring at fine geographic scales for conservation of the species:

> Fishery management and conservation actions affecting coho salmon in Alaska must recognize that the genetic population structure of coho salmon occurs on a fine geographic scale. Activities or conditions that cause declines in population abundance are more likely to have strong negative impacts for coho than for species in which genetic variation is distributed over a broader geographic scale (e.g., chum salmon). Coho salmon are probably more susceptible to extirpation, less likely to be augmented or "rescued" by other populations through straying (gene flow), **and the loss of populations means loss of significant amounts of overall genetic variability. These risks underscore the importance of single populations to the long term viability of coho salmon in Alaska and justify managing and conserving coho salmon at a fine geographic scale**. (Page 568) [emphasis added]

Chinook Salmon populations also tend to be relatively small (Healey 1991) and exhibit a diversity of life history traits (e.g., variations in size and age at migration, duration of freshwater and estuarine residency, time of ocean entry) (Lindley et al. 2009). Chinook Salmon populations in the Togiak River exhibit differences in spawning habitats (mainstem versus tributary) and migration timing, which translate to a clear stock structure (Sethi and Tanner 2014, Clark et al. 2015). Patterns of genetic differentiation between upstream and downstream populations along the same river network have also been found for other salmonids (Olsen et al. 2011, Ackerman et al. 2013, Barclay and Habicht 2019, Miettinen et al. 2021). Chinook Salmon populations in western Alaska similarly show fine-scale population differences across the four major regions (Norton Sound, the Yukon River, the Kuskokwim River, and Bristol Bay). This finding supports the contention that discrete Chinook Salmon populations likely exist in this region, which includes the Koktuli River (Larson et al. 2014, McKinney et al. 2020). Brennan et al. (2019) provide further support for this contention, demonstrating that the relative productivity of different portions of the Nushagak River varies over relatively short (1- to 4-year) time frames for both Chinook and Sockeye salmon.

Because Sockeye, Coho, and Chinook salmon spend a year or more rearing in freshwater streams, the survival and reproductive success of these species are highly reliant on high-quality freshwater habitats and habitat complexity. Loss of these habitats would affect multiple age classes of these species (e.g., potentially eggs, age-1 fish, and age-2 fish), with detrimental effects on adult returns of those age classes. Thus, reliance on freshwater habitats for longer periods of time increases the vulnerability of small, discrete populations of these species to losses of freshwater habitats, such as those resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan. The importance of maintaining the diversity among populations (e.g., in terms of migration timing, other life history traits, and genetic composition) for long-term population persistence and sustainability has been well-documented (Moore et al. 2014 , Schindler et al. 2010, Brennan et al. 2019, Davis and Schindler 2021). Loss of any genetically distinct populations in the SFK, NFK, or UTC watersheds would constitute a measurable adverse effect, in addition to any effects these losses may have at the scale of the entire Bristol Bay watershed via the portfolio effect (Section 3.3.3).

Thus, the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams represents a significant loss of anadromous fish habitat and would also reduce both habitat complexity and biocomplexity in the NFK watershed In addition, biocomplexity at relatively localized geographic scales contributes to the resilience and persistence of downstream populations. Biocomplexity, operating across a continuum of nested spatial and temporal scales, acts to buffer salmon populations from sudden and extreme changes in abundance, thereby maintaining overall salmon productivity (Section 3.3.3). Brennan et al. (2019: Page 785) underscore the critical role that streams and other aquatic habitats across the entire Nushagak River watershed, including those that would be adversely affected by the 2020 Mine Plan, play in stabilizing the Nushagak River's productive Sockeye and Chinook salmon fisheries, concluding that "[u]ltimately, entire landscapes are involved in stabilizing biological production."

4.2.1.3 Adverse Effects from Permanent Loss of Ecological Subsidies to Anadromous Fish Streams Downstream of the Mine Site

The permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams would also adversely affect downstream anadromous fish habitat (i.e., downstream anadromous fishery areas, including spawning and breeding areas). The following downstream secondary effects would result from the loss of these anadromous fish streams: reduced primary production, reduced nutrient cycling, reduced or lost gravel recruitment, reduced terrestrial inputs, and altered water chemistry (USACE 2020a: Section 4.24). These impacts "would be certain to occur if the project is permitted and constructed" (USACE 2020a: Page 4.24-9).

Coho, Chinook, and Sockeye salmon spawn and Coho and Chinook salmon rear in stream reaches immediately downstream of the 8.5 miles (13.7 km) of anadromous fish streams that would be permanently lost as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan (Figures 3-5 through 3-7and Figures 4-3 and 4-4). These downstream spawning and rearing areas would be damaged by the loss of the ecological subsidies provided by the 8.5 miles (13.7 km) of anadromous fish streams that would be destroyed.

Because of their crucial influence on downstream water flow, chemistry, and biota, impacts on headwaters reverberate throughout entire watersheds (Freeman et al. 2007, Meyer et al. 2007, Colvin et al. 2019, Koenig et al. 2019, French et al. 2020). As described in Section 3.2.4, headwater streams such as the 8.5 miles (13.7 km) of anadromous fish streams that would be permanently lost are important sources of water, nutrients, organic material, macroinvertebrates, and algae for habitats lower in the watersheds, and thereby provide important year-round subsidies for juvenile salmonids in those lower watershed habitats (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Wipfli et al. 2007, Colvin et al. 2019). For example, Alexander et al. (2007) found that perennial headwaters have a significant influence on downstream water quality and quantity, contributing roughly 55 percent of mean annual water volume and 40 percent of nitrogen flux in fourth and higher-order streams and rivers. This example highlights the critical role that headwaters play in determining the structure and function of larger downstream areas (Section 3.2.4). Where they provide salmon spawning areas, the anadromous fish streams that would be permanently lost are also a source of marine-derived nutrients for downstream waters (Section 3.3.4). Thus, elimination of these spawning areas would reduce the

downstream transport of these marine-derived energy subsidies resulting in damage to downstream anadromous fishery areas.

Permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams due to discharges of dredged or fill material associated with the 2020 Mine Plan would also fundamentally alter surface water and groundwater hydrology and, in turn, the flow regimes of receiving—or formerly receiving—streams. Such alterations would reduce the extent and frequency of stream connectivity to off-channel habitats, as well as reduce groundwater inputs and their modifying influence on the thermal regimes of downstream habitats, including spawning, rearing, and overwintering areas (Section 4.2.4). Lost streams also would no longer support or export macroinvertebrates, which are a critical food source for juvenile salmon, resident salmonids, and other biota, resulting in further damage to downstream anadromous fishery areas.

This damage to downstream anadromous fishery areas in the NFK watershed and the resulting effects on salmon populations that rely on those habitats would erode habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining the stability and productivity of these populations. (Section 4.2.1.2).

4.2.1.4 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 8.5 miles (13.7 km) of anadromous fish streams that would be lost under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these anadromous fish streams is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks.

Based on currently available fish survey data (ADF&G 2022a), the anadromous fish streams that would be permanently eliminated support three non-anadromous salmonid species (Rainbow Trout, Dolly Varden, and Arctic Grayling) and one other resident fish species (Slimy Sculpin) (Figures 4-4 through 4-7). Rainbow Trout, Dolly Varden, and Arctic Grayling are targets of downstream subsistence and recreational fisheries. Slimy Sculpin support those fisheries as forage fish (Section 3.3.1). The three non-anadromous salmonid species likely migrate substantial distances (120 miles [200 km] to 200 miles [320 km]) within their freshwater habitats (Section 3.3.1), suggesting that individuals move between headwaters and downstream areas. Most of the individuals observed in fish surveys in the 2020 Mine Plan footprint area were juveniles or sub-adults (ADF&G 2022a), further supporting that fishes rearing in headwater tributaries may contribute to downstream harvests.

Figure 4-3. Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

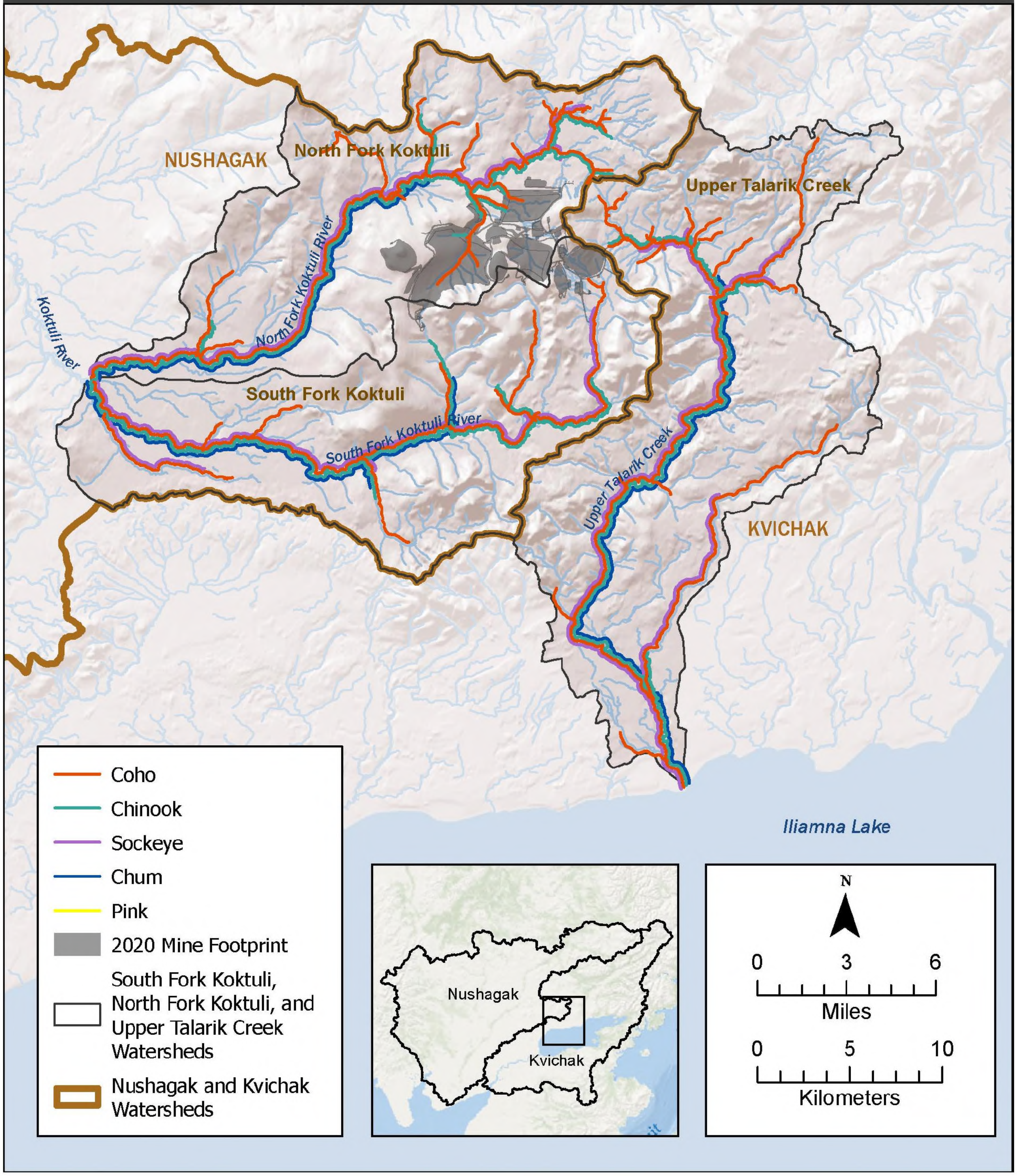


Figure 4-4. Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

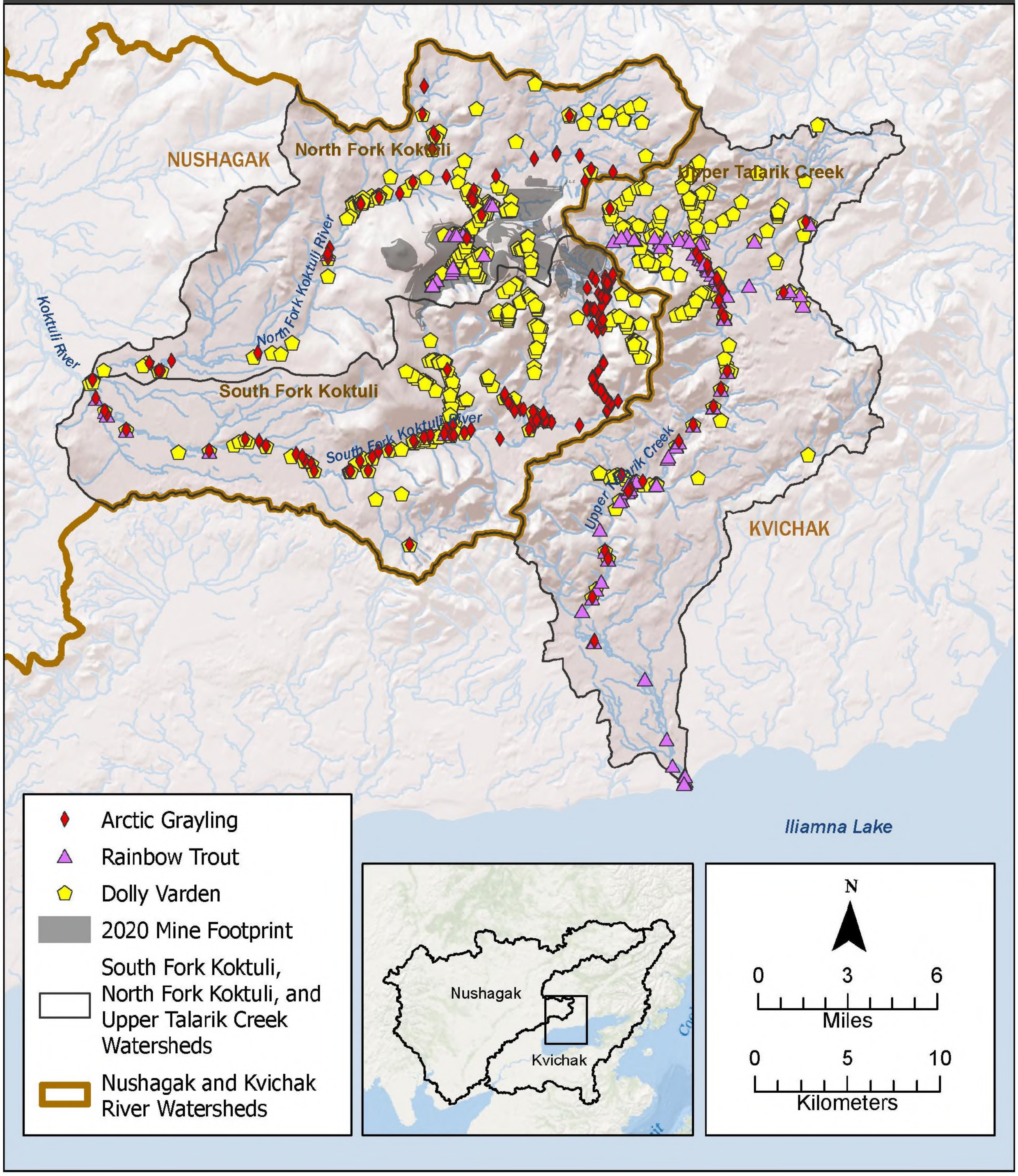


Figure 4-5. Reported occurrence of other resident fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

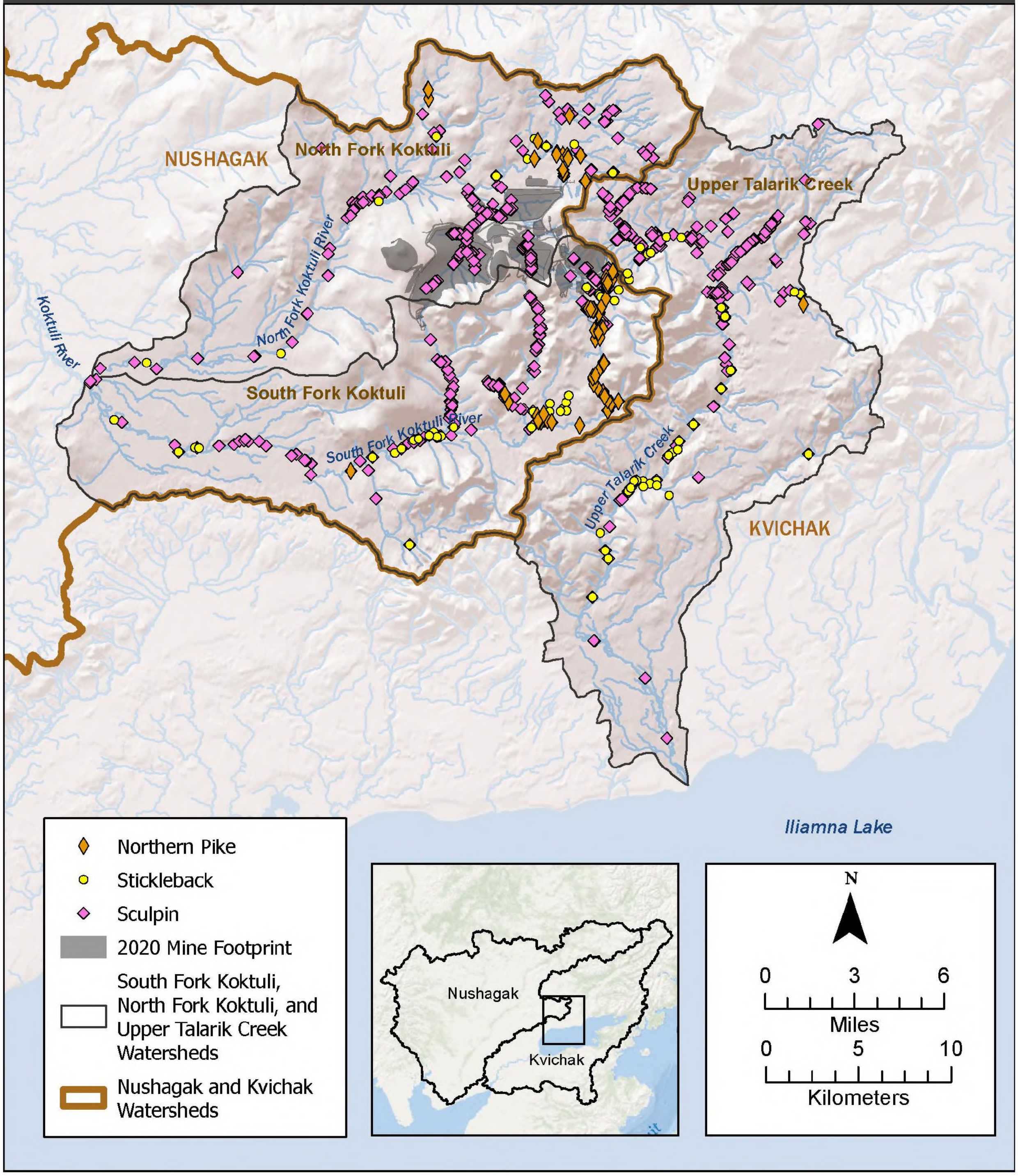


Figure 4-6. Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden overlain with the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

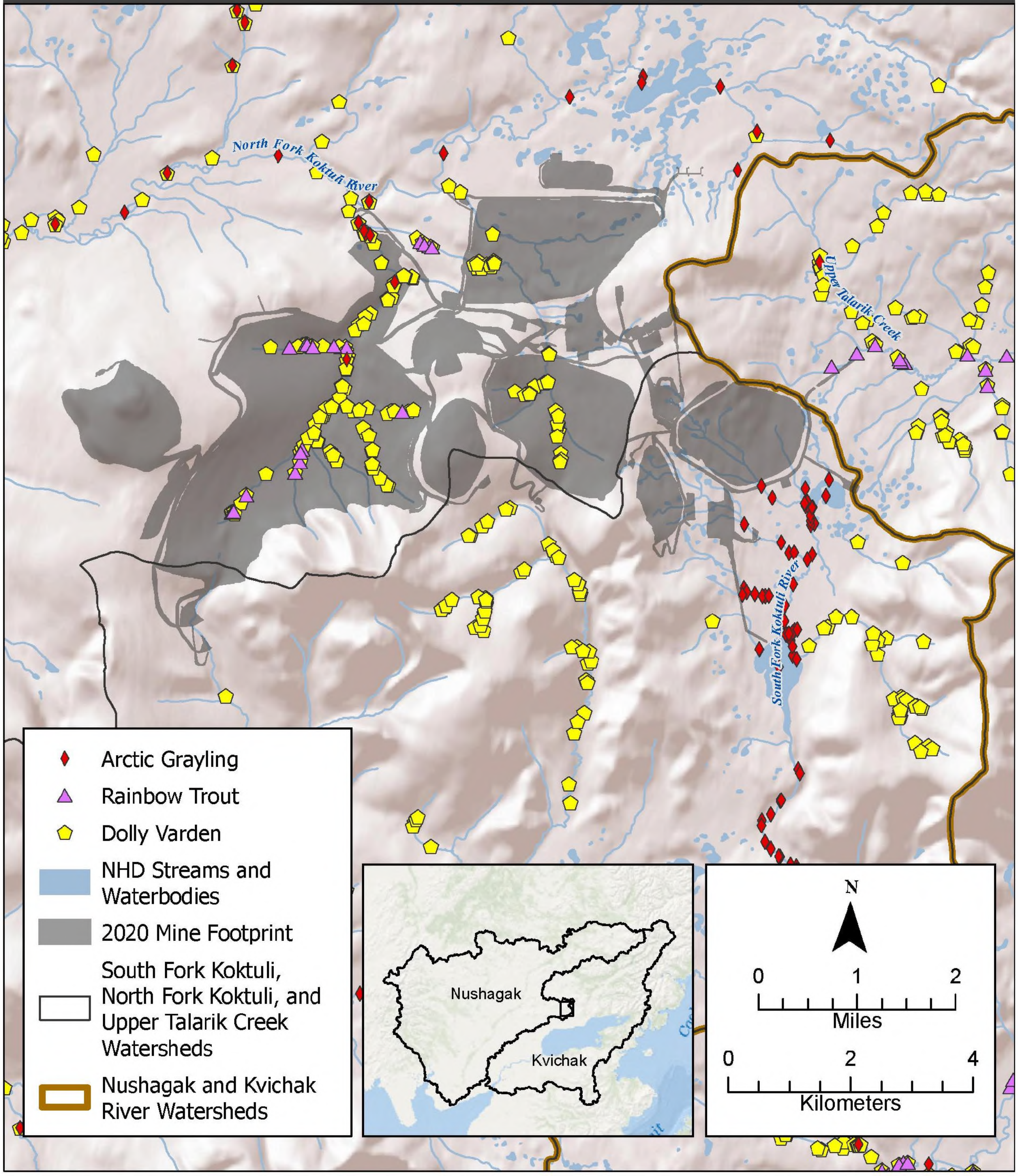
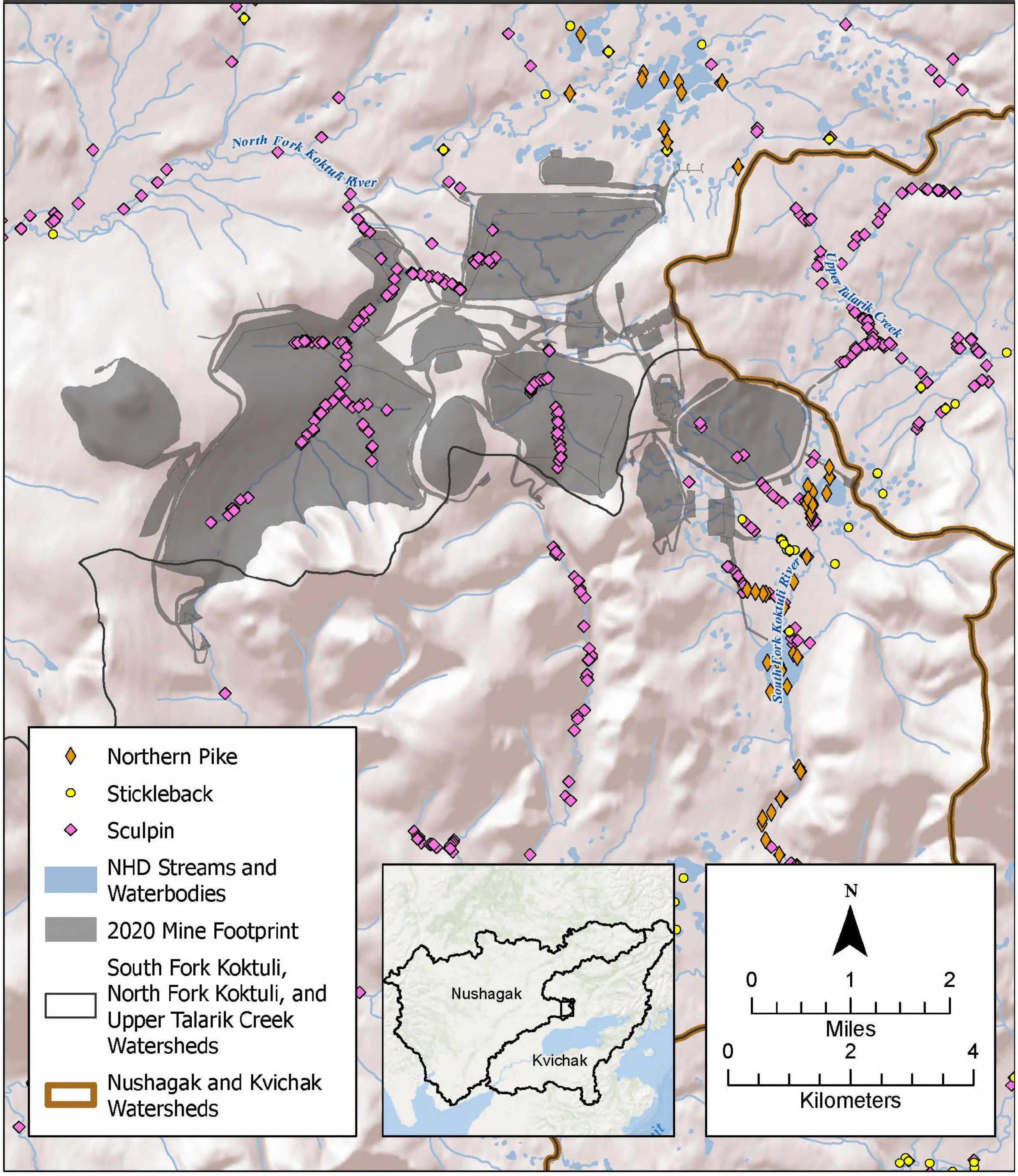


Figure 4-7. Reported occurrence of other resident fish species overlain with the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).



4.2.1.5 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.1.5.1 Adverse Effects of Loss of Anadromous Fish Streams at the Mine Site

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the NFK watershed. This conclusion is based on the following factors described in detail in Sections 4.2.1.1 through 4.2.1.3: the large amount of permanent loss of anadromous fish habitat (including spawning and breeding areas); the particular importance of the permanently lost habitat for juvenile Coho and Chinook salmon; the degradation of and thus damage to additional downstream spawning and rearing habitat for Coho, Chinook, and Sockeye salmon due to the loss of ecological subsidies provided by the eliminated anadromous fish streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the NFK watershed, both of which are key to the abundance and stability of salmon populations within this watershed.

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles of anadromous fish streams that would be eliminated by discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these anadromous fish streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.1.5.2 Adverse Effects of Loss of Anadromous Fish Streams Elsewhere in the SFK, NFK, and UTC Watersheds

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan

represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[62]

Thus, this final determination considers the effects of relocating the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 cubic feet per second [ft^3/s] or ≤0.15 cubic meters per second [m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-

[62] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation, and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams.[63] The permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit in any part of the SFK, NFK, and UTC watersheds would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of salmon spawning and rearing habitat and downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Permanent loss of these fishery areas would result in the permanent loss of their functional and productive capacity to support anadromous fishes, as well as resident fishes and other aquatic biota. Although salmon may attempt to occupy nearby habitats when displaced from their natal streams, this displacement can reduce their reproductive fitness (e.g., via reduced habitat quality, delayed occupancy of spawning habitats, and competition with fishes adapted to those nearby habitats). The functional and productive capacity of remaining downstream fishery areas also would be damaged, due to the loss of ecological subsidies to downstream anadromous fish habitats. Ultimately, these large losses of anadromous fish habitat, including habitats comprising unique combinations of habitat components to which anadromous fish populations have adapted can reduce the productivity and resilience of the salmon populations they support.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that the anadromous fish streams throughout these watersheds are currently among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large amount of permanent loss of anadromous fish habitat that approximately 8.5 miles (13.7 km) would represent; the degradation of and thus damage to additional downstream anadromous fish habitat due

[63] The FEIS concluded that placement of a bulk TSF at other locations in the SFK, NFK, or UTC watersheds would result in similar or greater losses of documented anadromous fish streams than the bulk TSF location proposed in the 2020 Mine Plan (PLP 2018e: RFI 098).

to the loss of ecological subsidies provided by the anadromous fish streams that would be lost; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams

In addition to the permanent loss of approximately 8.5 miles (13.7 km) of documented anadromous fish streams, discharges of dredged or fill material at the mine site for the 2020 Mine Plan would result in the permanent loss of approximately 91 miles (147 km)[64] of additional streams that support anadromous fish streams[65] in the SFK and NFK watersheds (USACE 2020a: Section 4.24) (Figure 4-8, Box 4-3). EPA has determined that the permanent loss of these additional streams will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. As discussed in this section, this conclusion is based on the extensive permanent loss of additional streams that support anadromous fish streams and the permanent loss of the ecological subsidies these additional streams provide to downstream anadromous fish streams, which represent significant damage to these downstream anadromous fishery areas.

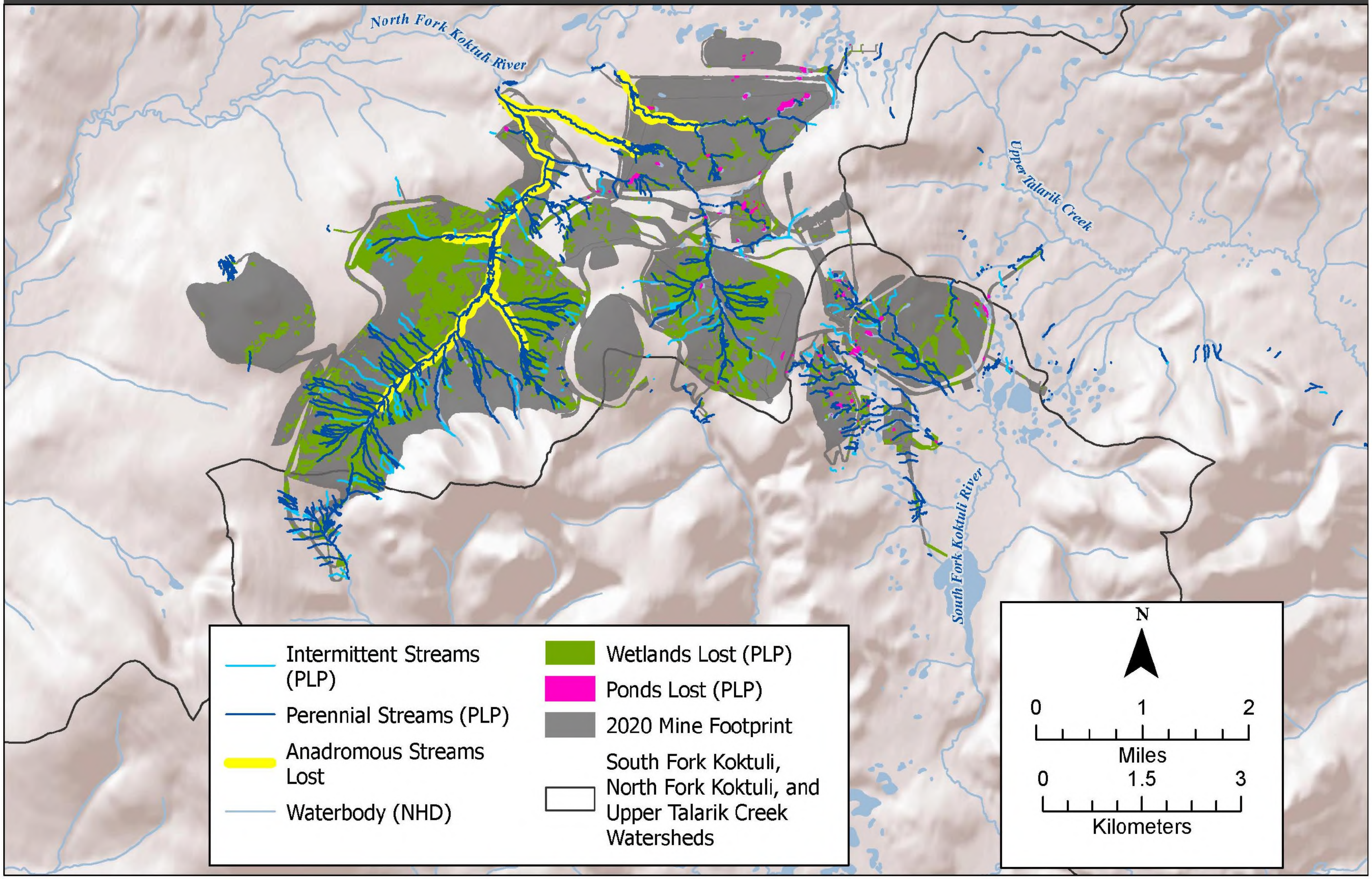
4.2.2.1 Extent of Additional Streams that Support Anadromous Fish Streams that Would Be Permanently Lost

Streams in the mine site area (Figures ES-5 and 4-8) were analyzed in detail to identify "all aquatic habitats potentially directly or indirectly affected by permitted mine site activities" (USACE 2020a: Page 4.24-1). The FEIS identifies 99.7 miles of streambed habitat at the mine site that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan. This loss includes the 8.5 miles of anadromous fish stream losses discussed in Section 4.2.1 (USACE 2020a: Section 4.24). Most of these losses would be located in the NFK watershed, where 72.4 miles (116.5 km) of additional streams would be permanently lost (in addition to the 8.5 miles [13.7 km] of anadromous fish stream losses). Permanent losses of additional streams in the SFK and UTC watersheds would be 18.8 miles (30.3 km) and 0.02 mile (0.02 km), respectively (PLP 2020b). The FEIS indicates the combined 99.7 miles (160.5 km) of anadromous fish stream and additional stream losses would represent "about

[64] According to the FEIS, "[a] total of 80 miles of stream habitat would be eliminated in the NFK drainage, including 8.5 miles of anadromous Pacific salmon habitat" and "a total of 19 miles of stream habitat would be eliminated in the SFK drainage" (USACE 2020a: Page 4.24-9). According to PLP's June 8, 2020 CWA Section 404 permit application, additional stream losses in the UTC would be less than 0.02 mile (PLP 2020b).

[65] *Additional streams that support anadromous fish streams* refers to streams that do not currently have documented anadromous fish occurrence. As explained in this section, such streams support downstream anadromous fish streams. Although there is not currently documented anadromous fish occurrence in these streams, they may nonetheless be used by anadromous fish; however, the potential for such use is not a basis for this final determination (see Box 4-2 and Appendix B).

Figure 4-8. Streams, wetlands, and ponds lost under the Pebble 2020 Mine Plan. Streams, wetlands, and ponds at the mine site are based on PLP's June 2020 Permit Application (PLP 2020b).



BOX 4-3. WATER RESOURCES MAPPING AT THE MINE SITE

As shown in Figure 4-8, PLP completed field-verified mapping of wetlands and other waters at the mine site. This type of higher resolution stream and wetland mapping would be necessary to accurately predict impacts on water resources from the discharge of dredged or fill material for the purposes of any final determination in this case. Project-specific map layers provide more detail and include more water courses than publicly available stream and wetland databases. A brief review of these databases is provided to demonstrate how the water resource impacts described in the FEIS and this final determination differ from the typical stream and wetland mapping available for the rest of the SFK, NFK, and UTC watersheds.

National stream and wetland databases are readily accessible for these watersheds, but these data come with limitations. The U.S. Geological Survey provides a nationwide database of streams, waterbodies, and watersheds as part of the National Hydrography Dataset (NHD). The NHD is a feature-based database that identifies stream segments or reaches that make up the nation's surface water drainage system. These data are mapped at 1:63,360 scale or larger in Alaska (USGS 2022). Similarly, the U.S. Fish and Wildlife Service maintains the National Wetlands Inventory (NWI) to provide information on the status, extent, characteristics, and functions of the nation's wetlands, riparian, and deepwater habitats (USFWS 2022a). The NWI mapping available for the SFK, NFK, and UTC watersheds is derived from 1:65,000 scale aerial photography (USFWS 2021). While NWI is not available nationwide, it is currently available for approximately 96 percent of the SFK, NFK, and UTC watersheds.

The stream and wetland mapping generated by PLP was developed using more site-specific information than is typically used in the development of the NHD or the NWI. For approximately 44 percent of the SFK, NFK, and UTC watershed areas, PLP developed high resolution vegetation and stream mapping layers using a combination of field data collection and aerial photography interpretation. Wetland boundaries were digitized on aerial photography at a scale between 1:1,200 and 1:1,500. Waterbodies were digitized based on aerial photography scaled at 1:400 using an average minimum mapping unit of 0.05 acre (USACE 2020a: Section 3.22). This mapping addressed some data gaps that otherwise exist when using non-project–specific stream and wetland mapping layers like the NHD or the NWI.

A comparison of these stream and wetland mapping sources helps demonstrate how impacts on water resources can appear to vary due solely to changes in map resolution. EPA understands the area under the 2020 Mine Plan footprint was subject to more review by USACE during the CWA Section 404 permit review process. Therefore, this area is assumed to provide the most accurate comparison area of national datasets to higher resolution water resources maps. While the NHD only shows approximately 25.8 miles (41.5 km) of streams under the 2020 Mine Plan footprint (USGS 2021b), PLP identified 99.7 miles (160.5 km) of stream habitat that would be impacted in this same area, including the 8.5 miles (13.7 km) of streams documented to contain anadromous fishes (USACE 2020a: Section 4.24). These values indicate there may be almost four times as many streams in these headwater areas than are mapped in the NHD. As indicated in the FEIS, PLP's identification of additional small-scale watercourses resulted in an increase in stream miles expected to receive direct and indirect impacts in the mine site analysis areas than had been disclosed in the DEIS (USACE 2020a: Section 4.22).

Similarly, while PLP's CWA Section 404 application identified 2,113 acres (8.6 km^2) of wetlands and other waters that would be permanently lost due to the discharge of dredged or fill material at the mine site, the NWI identified only 1,492 acres (6.0 km^2) of wetlands and deepwater habitats in this same area. These values indicate that there may be over 40 percent more wetlands and other deepwater habitats in the vicinity of the Pebble deposit than are included in the NWI.

20 percent of available [stream] habitat in the Headwaters Koktuli River [watershed]" (i.e., the SFK, NFK, and Middle Koktuli River HUC-12 watersheds) and "12 percent of available [stream] habitat in the larger Koktuli River [watershed]" (USACE 2020a: Page 4.24-8).[66]

[66] EPA acknowledges that water resources have not been consistently mapped across these watersheds (USACE 2020a: Page 4.24-8). Nonetheless, the 2020 Mine Plan would result in the permanent loss of at least approximately 100 miles of headwater streams, which is the focus of Sections 4.2.1 and 4.2.2.

4.2.2.2 Adverse Effects from Permanent Loss of Additional Streams that Support Anadromous Fish Streams

The permanent loss of approximately 91 miles (147 km) of additional streams from discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in reduced stream productivity in downstream anadromous fishery areas of the SFK and NFK due to the loss of physical and biological inputs that would no longer be provided to downstream fishery areas that support Coho, Chinook, Sockeye, and Chum salmon. These reductions in productivity would be permanent and certain to occur (USACE 2020a: Section 4.24).

The majority of the additional streams that would be permanently lost are small headwater streams. An extensive body of scientific evidence demonstrates that headwater streams are important aquatic habitats and play a critical role in the structure and function of downstream reaches (Section 3.2.4). The small size and large collective surface area of headwater streams result in a disproportionate effect on larger downstream habitats (Vannote et al. 1980, Alexander et al. 2007, Koenig et al. 2019, Colvin et al. 2019). Thus, loss of these headwater streams and their important ecological subsidies (e.g., food resources, nutrients, surface water flows, groundwater exchange) can have larger than expected impacts on downstream reaches. Headwater streams that the 2020 Mine Plan would eliminate contribute spawning gravels, invertebrate drift, organic matter, nutrients, surface water flows, groundwater flows, and woody debris to downstream channels (USACE 2020a: Section 4.24). The loss of temperature moderation via groundwater-influenced flows to downstream anadromous fish streams would exacerbate the potentially substantial changes in stream temperature caused by WTP discharges (USACE 2020a: Section 4.24). Headwater streams also can serve as refugia for fishes that may seasonally or periodically use these habitats (USACE 2020a: Section 3.24). For example, headwater streams can provide refuge from predators (Sepulveda et al. 2013), floods (Brown and Hartman 1988), or otherwise temporarily inhospitable conditions in downstream waters. Indeed, the capacity and tendency of juvenile salmonids (e.g., Coho Salmon) to move extensively within the stream system, including upstream movements of kilometers, is becoming increasingly apparent (e.g., Kahler et al. 2001, Anderson et al. 2013, Armstrong and Schindler 2013, reviewed by Shrimpton et al. 2014).

The 91 miles (147 km) of additional streams that would be permanently lost in the SFK and NFK watersheds as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan provide important provisioning functions (via ecological subsidies) and habitat functions (via refugia) that are beneficial for downstream anadromous fishery areas. As a result, headwater streams such as those that would be permanently lost in the mine site area play a vital role in maintaining diverse, abundant anadromous fish populations (Section 3.2.4). Losses of this magnitude would result in significant damage to downstream anadromous fishery areas that provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8, Figures 4-2 and 4-3). These losses would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK), as well as Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1).

As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss of and damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 91 miles (147 km) of additional streams would further erode habitat complexity and biocomplexity within these watersheds. This diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations. By itself, without contemplation of any other certain losses, the permanent destruction of approximately 91 miles (147 km) of additional streams from a single project would be unprecedented for the CWA Section 404 regulatory program in the Bristol Bay watershed. Such losses are unprecedented for good reason: the effects of these additional stream losses would degrade downstream habitats and adversely affect species such as Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds, all of which support important subsistence, commercial, and recreational fisheries.

Other streams in the mine site area are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated as a result of the discharges of dredged or fil material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8).

4.2.2.3 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 91 miles (147 km) of additional streams that support anadromous fishery areas in the SFK and NFK watersheds and would be lost under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these additional streams is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks.

The permanent loss of approximately 91 miles (147 km) of additional streams from the discharge of dredged or fill material under the 2020 Mine Plan would adversely affect non-anadromous fish species and assemblages. Available data indicate that approximately 14.1 miles (22.7 km) of these 91 miles (147 km) of additional streams support non-anadromous fish species such as Rainbow Trout, Dolly Varden, Arctic Grayling, Ninespine Stickleback, and Slimy Sculpin (Figures 4-6 and 4-7). Approximately 1.4 miles (2.3 km) of streams in the SFK watershed that would be lost to the mine footprint (Figure 4-8; USACE 2020a: Section 4.24) provide habitat for Arctic Grayling, Northern Pike, Slimy Sculpin, and Ninespine Stickleback. The remaining 12.7 miles (20.4 km) that would be permanently lost are located in the NFK watershed (USACE 2020a: Section 4.24) and provide habitat for Dolly Varden, Rainbow Trout, and Slimy Sculpin (ADF&G 2022a). As described in Section 4.2.1, Rainbow Trout, Dolly Varden, and Arctic Grayling are targets of downstream subsistence and recreational fisheries. Stickleback and Slimy Sculpin support those fisheries as forage fishes (Table 3-3).

As discussed previously in this section, waters downstream of the mine site would be degraded as a result of the elimination of 91 miles (147 km) of additional streams at the mine site. In addition to the four Pacific salmon species already discussed, these waters support Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimly Sculpin. Thus, the ecological value of the approximately 91 miles (147 km) of additional streams that would be eliminated is further highlighted by the fact that they provide both habitat and habitat support functions for six non-anadromous fish species important to subsistence and recreational fisheries and aquatic food webs (Section 3.3.1).

4.2.2.4 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.2.4.1 Adverse Effects of Loss of Additional Streams at the Mine Site that Support Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 91 miles (147 km) of additional streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.2.1 and 4.2.2.2: the large amount of permanent loss of additional streams and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of and thus damage to downstream anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, due to the loss of ecological subsidies provided by the eliminated headwater streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK and NFK watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

Other streams in the mine site area are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated by the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these additional streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK

watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.2.4.2 Adverse Effects of Loss of Additional Streams Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[67]

Thus, this final determination considers the effects of relocating the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

[67] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

An extensive body of scientific evidence demonstrates that headwater streams play a critical role in the structure and function of downstream reaches, by providing important fish habitat and supplying the energy and other resources needed to support fishes in connected downstream habitats (Section 3.2.4). Headwater streams transport invertebrates and detritus to downstream areas, where these resources support juvenile salmonids and other fishes (Wipfli and Gregovich 2002, Cummins and Wilzbach 2005, Colvin et al. 2019, Hedden and Giddo 2020). Headwater streams also influence downstream water chemistry (Richardson et al. 2005, Alexander et al. 2007, Meyer et al. 2007). Together, the small size and large collective surface area of headwater streams result in a disproportionate effect on larger downstream habitats (Vannote et al. 1980, Alexander et al. 2007, Koenig et al. 2019, Colvin et al. 2019). Because of their large influence on downstream water flow, water chemistry, and biota, the importance of headwater systems reverberates throughout entire watersheds downstream (Freeman et al. 2007, Meyer et al. 2007, Fritz et al. 2018, Schofield et al. 2018, Ferreira et al. 2022).

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 91 miles (147 km) of additional headwater streams at the mine site that support anadromous fish streams. The permanent loss of approximately 91 miles (147 km) of additional headwater streams that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit, in any part of the SFK, NFK, and UTC watersheds, would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Losses of this magnitude would eliminate substantial downstream ecological subsidies of surface water flows, energy, substrate, nutrients, organic matter, macroinvertebrates, and other materials, resulting in significant damage to downstream anadromous fishery habitats, including downstream salmon spawning and rearing habitats, leading to erosion of habitat complexity and biocomplexity. Ultimately, these significant permanent losses of additional streams that support anadromous fish streams would therefore reduce the functional and productive capacity of these downstream anadromous fishery areas to support anadromous fishes, as well as resident fishes and other aquatic biota.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other

locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: headwater streams throughout the SFK, NFK, and UTC watersheds are among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1) and play a critical role in supporting productive and diverse Pacific salmon populations (Section 3.2); headwater streams across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of stream habitat and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of and thus damage to downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

In addition to the losses of anadromous fish streams and additional streams that support anadromous fish streams, the discharge of dredged or fill material at the mine site for the construction and routine operation of the 2020 Mine Plan would also result in the permanent loss of approximately 2,113 acres (8.6 km^2) of wetlands and other waters in the SFK, NFK, and UTC watersheds; approximately 2,108 acres (8.5 km^2) of these losses would occur in the SFK and NFK watersheds (Figure 4-8, Table 4-3, see also Box 4-3) (USACE 2020a, USACE 2020b). EPA has determined that these permanent losses of wetlands and other waters will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. As discussed in this section, this conclusion is based on the extensive permanent loss of wetlands and other waters and the corresponding permanent loss of ecological subsidies these wetlands provide to downstream anadromous fish streams, which represent significant damage to these downstream anadromous fishery areas.

Table 4-3. Area of wetlands and other waters lost under the Pebble 2020 Mine Plan.

Hydrogeomorphic/National Wetland Inventory (NWI) Group			Headwaters Koktuli River [a]	Upper Talarik Creek [b]	Combined Watershed Area (acres)
SLOPE	Wetlands	Total Wetlands	1,909	4	1,913
		Herbaceous	547	1	547
		Deciduous Shrubs	1,352	3	1,355
		Evergreen Shrubs	11	—	11
	Other Waters	Total Other Waters	16		16
		Aquatic Bed	2	—	2
		Ponds	13	—	13
		TOTAL SLOPE	1,925	4	1,929
DEPRESSIONAL	Wetlands	Total Wetlands	12	<1	12
		Herbaceous	5	<1	5
		Deciduous Shrubs	7	—	7
	Other Waters	Total Other Waters	38	<1	39
		Ponds	38	<1	39
		TOTAL DEPRESSIONAL	50	<1	50
FLAT	Wetlands	Total Wetlands	8		8
		Herbaceous	3	—	3
		Deciduous Shrubs	6	—	6
		TOTAL FLAT	8		8
LACUSTRINE FRINGE	Wetlands	Total Wetlands	<1		<1
		Herbaceous	<1	—	<1
		TOTAL LACUSTRINE FRINGE	<1		<1
RIVERINE	Wetlands	Total Wetlands	118		118
		Herbaceous	42	—	42
		Deciduous Shrubs	76	—	76
	Other Waters	Total Other Waters	7		7
		Ponds	7	—	7
		TOTAL RIVERINE	125		125
Total Impacts to Wetlands (acres)			**2,047**	**4**	**2,051**
Total Impacts to Other Waters (acres)			**61 [c]**	**<1**	**61 [c]**
Total Impacts to Wetlands and Other Waters (acres)			**2,108 [c]**	**4**	**2,113 [c]**
Total Area of NWI Wetlands and Other Waters (acres)			**36,458**	**13,193**	**49,651**
Percent Total of NWI Wetlands and Other Waters			**6**	**<1**	**4**

Notes:

[a] 100 percent of the Headwaters Koktuli River watershed has been mapped in NWI.

[b] 91 percent of the Upper Talarik Creek watershed has been mapped in NWI.

[c] To be consistent with the USACE's ROD (USACE 2020b), stream area was removed from values presented in FEIS Table 4.22-3 such that the Other Waters acreage values only include the following NWI group types: aquatic bed and ponds (USACE 2022).

Source: Adapted from FEIS Table 4.22-3 (USACE 2020a).

4.2.3.1 Extent of Wetlands and Other Waters that Support Anadromous Fish Streams that Would Be Permanently Lost

The FEIS states that the permanent "loss of wetlands from development of the mine site represent about 6 percent of mapped wetlands in the Headwaters Koktuli River watershed" (USACE 2020a: Page 4.22-

13)[68] (i.e., the SFK, NFK, and Middle Koktuli River HUC-12 watersheds) and 4 percent of mapped wetlands in the Headwaters Koktuli River and UTC watersheds (Table 4-3, Box 4-3) (USACE 2020a: Section 4.22).

4.2.3.2 Adverse Effects from Permanent Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

The FEIS evaluates the "potential direct and indirect impacts from construction and operations" of the 2020 Mine Plan on wetlands and other waters across the mine site area (Figure ES-5) (USACE 2020a: Page 4.22-1). Wetlands and other waters that would be permanently lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan play a critically important role in the life cycles of anadromous fishes in the SFK and NFK watersheds (Section 3.2.3) (PLP 2011: Appendix 15.1.D). "[A]ll wetlands are important to the greater function and value of ecosystems and subsistence cultures they support" (USACE 2020a: Page 3.22-8). In addition, the wetlands and other waters that would be lost or damaged by the discharges of dredged or fill material associated with the 2020 Mine Plan "possess unique ecological characteristics of productivity, habitat, wildlife protection, and other important and easily disrupted values" (USACE 2020a: Page 3.22-1). The specific wetlands and other waters that would be permanently lost are also relatively free from human-induced alteration and provide extensive and heterogeneous habitats (Table 4-3) (USACE 2020a: Section 3.22). These wetlands and other waters are a key component of the diverse portfolio of pristine aquatic habitats that is crucial to supporting the productivity and stability of salmon populations in these watersheds (Section 3.3.3).

The permanent loss of wetlands and other waters would destroy habitat, result in mortality of aquatic organisms, and reduce the collective functional capacity and value of wetlands and other waters across multiple watersheds (USACE 2020a: Section 4.22). The permanent loss of wetlands and other waters also would cause the displacement, injury, and/or mortality of species that rely on these aquatic environments for all or part of their life cycles (USACE 2020a: Section 4.22). Under these circumstances, sedentary aquatic species (e.g., mollusks, fixed crustaceans, and benthic organisms) are likely to suffer mortality from sedimentation or smothering by fill; mobile species (e.g., fishes, free-swimming crustaceans, amphibians, and macroinvertebrates) may attempt to relocate (USACE 2020a: Section 4.22). Highly mobile salmon may attempt to occupy nearby habitats when displaced from their natal aquatic habitats, but this displacement can reduce their reproductive fitness (e.g., via reduced habitat quality, delayed occupancy of spawning habitats, and competition with fishes adapted to those nearby habitats).

The discharge of dredged or fill material into wetlands and other waters for the construction and routine operation of the 2020 Mine Plan would eliminate the biological productivity of wetland ecosystems buried by fill and alter the periodicity of water movement (USACE 2020a: Section 4.22). The elimination of productivity and alteration of water current patterns and velocities would eliminate or

[68] In its comments on the proposed determination, PLP indicated that following publication of the FEIS it provided information to USACE that this value is 4.8 percent based on updated mapping results. This clarification does not change EPA's analysis since the absolute amount of loss has not changed.

reduce the cycling of nutrients and other materials. The disruption of wetland hydrology would interfere with the filtration, aquifer recharge, and storm and floodwater modification functions that wetlands provide (USACE 2020a: Section 4.22). Many of the affected wetlands in the mine site area (e.g., slope wetlands) are considered headwater wetlands from a watershed perspective, meaning they are the primary source of intermittent and upper perennial streams. Impacts to these wetlands would alter groundwater discharges that maintain hydrology and water quality and buffer water temperatures in these streams; this alteration of hydrologic function is likely to extend to wetlands and other waters immediately downgradient from the affected wetlands (USACE 2020a: Section 4.22). All of these changes will significantly degrade these wetlands and other waters as habitat for anadromous fish and the ability of these wetlands and other waters to provide ecological subsides to downstream anadromous fishery areas.

Changes in flow in the SFK, NFK, and UTC due to modification of upgradient wetlands and mine operations have the potential to change the hydrologic connectivity of off-channel habitats and associated wetlands (USACE 2020a: Section 4.22). Off-channel habitats, including fringing riparian wetlands, provide cover important to juvenile salmon rearing (Section 3.2) (USACE 2020a: Section 4.22). Changes to flow and loss of connectivity between wetlands and other waters and stream channels also would adversely affect nutrient availability, degrade the transport of invertebrates downstream, and reduce available habitat for benthic macroinvertebrate production, thereby adversely affecting overall productivity of downstream anadromous fish streams and other additional streams that support anadromous fish streams (USACE 2020a: Section 4.22).

As described in Section 4.2.1, the wetlands and other waters that would be permanently lost due to discharges of dredged or fill material associated with the 2020 Mine Plan include beaver ponds and wetlands inundated as a result of beaver activity (USFWS 2021). Coho and Chinook salmon rear in many of the beaver-modified waters or the streams they abut (Table 3-10). Beaver-modified waters provide excellent rearing habitat and important overwintering and flow-velocity refugia for anadromous fishes (Section 3.2.4) and may be especially important in maintaining salmon productivity (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004).

Wetlands in the SFK, NFK, and UTC watersheds that are contiguous with and adjacent to anadromous fish streams likely provide additional anadromous fish habitat. Such areas often provide habitat to juveniles of species such as Coho Salmon (Henning et al. 2006, EPA 2014: Appendix B). The lower gradient of lakes, ponds, and inundated wetlands connected to anadromous fish streams also can provide beneficial rearing and foraging conditions that may be unavailable in the mainstream channel (Sommer et al. 2001, Henning et al. 2006), thereby increasing capacity for juvenile salmon growth and rearing (Nickelson et al. 1992, Sommer et al. 2001).

Wetlands in the SFK, NFK, and UTC watersheds also indirectly support anadromous fish streams by providing cover; moderating stream temperatures and flows; maintaining baseflows; serving as groundwater recharge zones; and supplying nutrients, organic material, macroinvertebrates, algae, and other materials to abutting streams and streams lower in the watershed. These inputs serve as

important subsidies for juvenile salmonids (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Dekar et al. 2012, Doretto et al. 2020). Abundant wetlands and small ponds, for example, have been documented to contribute disproportionately to groundwater recharge in this region (Rains 2011). Given the importance of groundwater–surface water exchange in the SFK, NFK, and UTC watersheds, groundwater inputs are likely a significant determinant of surface water quantity and quality. Moreover, leaf litter from deciduous shrubs and herbaceous vegetation is an important food source for stream food webs and helps fuel the production of macroinvertebrates, a key food for juvenile salmonids (Table 3-3) (Meyer et al. 2007, Dekar et al. 2012). Riparian wetlands with deciduous shrubs and grasses are prevalent in the SFK, NFK, and UTC watersheds and likely provide this energy source to downgradient waters.

The permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan in the SFK and NFK watersheds would result in loss of both habitat and the provision of key ecological subsidies to abutting and downstream waters (Section 3.2.4). Loss of these wetlands and other waters as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan would eliminate structurally complex and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids. Such headwater wetlands also play a vital role in maintaining diverse, abundant anadromous fish populations via the downstream transport of surface and groundwater inputs and food sources critical to the survival, growth, and spawning success of anadromous fishes in downstream fishery areas (Section 3.2.4).

Downstream waters that would be degraded by the large-scale elimination of wetlands and other waters at the mine site are ecologically important and provide rearing and spawning habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8). In addition, damage to downstream anadromous fish streams would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and the NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1).

As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss of and damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from the elimination of approximately 2,108 acres (8.5 km^2) of wetlands and other waters would further erode habitat complexity and biocomplexity within the SFK and NFK watersheds. The diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations. By itself, without contemplation of any other certain losses, the permanent destruction of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from a single project would be unprecedented for the CWA Section 404 regulatory program in the Bristol Bay watershed. Such losses are unprecedented for good reason: the effects of these losses would degrade downstream habitats and adversely affect species such as Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds, all of which support important subsistence, commercial, and recreational fisheries.

Additional wetlands and other waters in the mine site area are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres of wetlands and other waters that would be eliminated as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan footprint (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These additional wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5).

The FEIS also indicates that additional wetlands and other waters adjacent to the mine site would be degraded by construction and operation of the 2020 Mine Plan. For example, fragmentation would occur between mine site infrastructure (Figure ES-5) (USACE 2020a: Section 4.22) and groundwater drawdown could potentially dewater wetlands located more than half a mile from mine infrastructure (USACE 2020a: Figure 4.22-3). Such indirect impacts would also contribute adverse effects to anadromous fish streams due to the loss of habitat connectivity and loss of ecological subsidies. Although not included as part of the permanent losses of wetlands and other waters identified for the 2020 Mine Plan, if these types of indirect impacts were to continue for more than 5 years they could result in permanent losses of these types of aquatic resources (Box 4-1).

4.2.3.3 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 2,108 acres (8.5 km^2) of wetlands and other waters at the mine site that would be lost in the SFK and NFK watersheds under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these wetlands and other waters is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks. Dolly Varden and sculpin rear in many of the same beaver-modified habitats as Coho and Chinook salmon, and Ninespine Stickleback and sculpin rear in headwater ponds of the SFK watershed (Figures 4-6 and 4-7). Furthermore, waters downstream of the mine site that would be degraded by elimination of wetlands and other waters at the mine site support Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and sculpin—species that support regional biodiversity (Meyer et al. 2007) and are important to subsistence and recreational fisheries and aquatic food webs (Section 3.3.1).

4.2.3.4 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from the discharge of dredged or fill material associated with developing the Pebble deposit would affect abutting and downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure ES-5) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following

conclusions and rationale directly support the recommended prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.3.4.1 Adverse Effects of Loss of Wetlands and Other Waters at the Mine Site that Support Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.3.1 and 4.2.3.2: the large amount of permanent loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of and thus damage to downstream anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, due to the loss of ecological subsidies provided by the headwater wetlands and other waters that would be lost; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK and NFK watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

Additional wetlands and other waters in the mine site area are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres (8.5 km^2) of wetlands and other waters that would be eliminated by the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site in the SFK and NFK watersheds (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5). Thus, the same or greater levels of loss of these additional wetlands and other waters from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.3.4.2 Adverse Effects of Loss of Wetlands and Other Waters Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of

dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[69]

Thus, this final determination considers the effects of relocating the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem

[69] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

An extensive body of scientific evidence demonstrates that headwater wetlands play a critical role in the structure and function of abutting and downstream waters, by providing important fish habitat and

supplying the energy and other resources needed to support fishes in connected habitats (Section 3.2.4). Wetlands and other waters throughout the SFK, NFK, and UTC watersheds support abutting and downstream anadromous fish streams in multiple ways (Sections 3.2.4 and 4.2.3.2). Wetlands moderate streamflows by detaining water at the surface and within soils and serving as groundwater recharge zones. The eventual conveyance of this water to stream and river channels helps to maintain flows during periods without precipitation. Diverse off-channel habitats in the three watersheds provide habitat for Chinook, Coho, and Sockeye salmon, as well as other salmonids (Table 3-10). Thermally diverse habitats in off-channel wetlands provide rearing and foraging conditions that may be unavailable in the mainstream channel (e.g., warmer temperatures, lower water velocities, increased food availability), increasing capacity for juvenile salmon rearing (Brown and Hartman 1988, Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Sommer et al. 2001, Henning et al. 2006, Lang et al. 2006, PLP 2011). Beaver ponds and wetlands inundated by beaver activity can be especially important for maintaining salmon productivity (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004), through the provision of high-quality rearing habitat and important overwintering and flow-velocity refugia (Section 3.2.4). Wetlands also provide ecological subsidies to abutting streams and streams lower in the watershed, in the form of water, nutrients, organic material, macroinvertebrates, algae, and other materials (Section 3.2.4); these inputs can serve as important resources for juvenile salmonids (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Dekar et al. 2012, Doretto et al. 2020).

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters at the mine site that support anadromous fish streams. The permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit, in any part of the SFK, NFK, and UTC watersheds, would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of salmon habitat and downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Losses of this magnitude would eliminate nutrient-rich, structurally complex, and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids. In addition to the direct loss of habitat, loss of these wetlands, lakes, and ponds would also result in a total loss of their fish-habitat support functions for abutting and downstream waters (Section 3.2.4). The disruption of wetland hydrology would eliminate the flow modification functions of these habitats. The provision of ecological subsidies to downstream waters also would be eliminated, resulting in the degradation of downstream salmon spawning and rearing habitat. Ultimately, these significant permanent losses of wetlands and other waters that support anadromous fish streams would therefore reduce the functional and productive capacity of these downstream anadromous fishery areas to support anadromous fishes, as well as resident fishes and other aquatic biota.

Given the significant similarities in structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from discharges of dredged or fill material

associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: headwater wetlands and other waters throughout the SFK, NFK, and UTC watersheds are among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); these three watersheds have similar amounts and types of wetlands (Table 3-2); headwater wetlands and other waters across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of permanent loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of and thus damage to downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater wetlands and other waters; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan, resulting in streamflow changes greater than 20 percent of average monthly streamflow in at least 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the extent and magnitude of changes to streamflow in anadromous fish streams downstream of the mine site and associated adverse effects on the extent and quality of anadromous fish habitat, including spawning and rearing habitat, which represent significant damage to these downstream anadromous fishery areas.

This section first describes the methodology used for identifying anadromous fish stream reaches that would experience unacceptable adverse effects as a result of discharges of dredged or fill material associated with the 2020 Mine Plan (Section 4.2.4.1). This section then provides an overview of water management under the 2020 Mine Plan (Section 4.2.4.2), the extent of anadromous fish streams where adverse effects from streamflow changes would occur under the 2020 Mine Plan (Section 4.2.4.3), the anadromous fish habitat that would be affected (Section 4.2.4.4), and the adverse effects on anadromous fish streams that would result from the predicted streamflow alterations (Section 4.2.4.5). Impacts to other fish species are discussed (Section 4.2.4.6) and then conclusions are presented (Section 4.2.4.7).

4.2.4.1 Methodology for Analyzing Streamflow Changes in Downstream Anadromous Fish Streams

The natural flow regime, defined as the characteristic pattern of streamflow magnitude, timing, duration, frequency, and rate of change (Poff et al. 1997), plays a critical role in supporting and maintaining both the ecological integrity of streams and rivers and the services they provide. Each stream or river has a characteristic flow regime and a biotic community adapted to it, reflecting the importance of flow regime in creating and maintaining instream habitat and shaping the evolution of both ecological processes and aquatic biota (Bunn and Arthington 2002, Naiman et al. 2002, Annear et al. 2004). Human-induced alteration of the natural flow regime can degrade the physical, chemical, and biological properties of a waterbody, leading to loss of aquatic life and reduced aquatic biodiversity (e.g., Poff et al. 1997, Bunn and Arthington 2002, Naiman et al. 2002, Annear et al. 2004, Poff and Zimmerman 2010). Maintenance of natural flows and the patterns of longitudinal and lateral connectivity that result from these flows is essential to the viability of many riverine species (Bunn and Arthington 2002). Because flow regime directly or indirectly affects all other functions, flow regime is often considered the most significant stream function (Lytle and Poff 2004, Fischenich 2006, Sofi et al. 2020).

Aquatic ecologists have long recognized that a much fuller spectrum of flow conditions (e.g., base flows, high flows, flood flows) is needed to sustain native species than is provided by instream flow models, such as the Physical Habitat Simulation System (PHABSIM) model used to evaluate streamflow in the FEIS (Postel and Richter 2003). For example, Pahl-Wostl et al. (2013: Page 342) were critical of habitat-based approaches, stating "[e]arly static approaches aimed to define either minimum or average flows to support key fish species or maintain instream habitat (sometimes revealingly termed 'compensation flows'); but these are now viewed as too simplistic to support complex flow-dependent ecosystem functions." Such approaches predict benefits to fishes based on consideration of limited flow metrics such as water depth and velocity (Postel and Richter 2003) and do not account for other ecologically relevant fish habitat parameters, such as groundwater exchange, substrate, water temperature, water chemistry, cover, and habitat complexity (e.g., wetlands and other off-channel habitats) (Appendix B: Section B.4.2.1).

Protecting ecosystem integrity requires maintaining multiple components of the natural flow regime within their typical ranges of variability (Pahl-Wostl et al. 2013). This perspective requires an understanding of both natural flow regimes over space and time and the many ways in which aquatic habitats, species, and life stages respond to varied flow conditions (Warren et al. 2015, Novak et al. 2016, Flitcroft et al. 2016, Flitcroft et al. 2019).

For streams in the Bristol Bay region, natural temporal streamflow variability results from fall storm events, winter low flows under ice cover, spring snowmelt peak flows, and subsequent recession of streamflow into summer (EPA 2014: Chapters 3 and 7, USACE 2020a: Section 3.16). These seasonal flow regimes affect channel development and maintenance; connectivity between active channels and off-channel habitats; transport of sediment and nutrients; timing and success of fish migration and spawning; and survival of fish eggs and juveniles (EPA 2014: Chapter 7).

Recognizing the importance of natural flow regimes to habitat-forming processes and the biotic integrity of salmon ecosystems in the SFK, NFK, and UTC watersheds (EPA 2014: Chapter 7), EPA has evaluated the 2020 Mine Plan using projected streamflow changes from natural conditions in terms of percent change from natural flows. Such an approach targets functional hydrogeomorphic processes in the entire aquatic ecosystem, rather than focusing on a specific species or set of species (e.g., salmon) that may have different habitat requirements than other biota in the natural system.

Based on case studies from around the world and literature on ecological flows dating back to the 1970s, Richter et al. (2012) found that, regardless of geographic location, daily streamflow alterations of greater than 20 percent can cause major changes in the structure and function of streams. Streamflow alterations between 11 and 20 percent can also result in changes in ecosystem structure and function, but to a lesser extent; although Richter et al. (2012) note that limiting daily flow alterations to 20 percent or less may be protective in some circumstances, they also caution that it may be insufficient to fully protect ecological values in certain rivers. Because Pacific salmon are locally adapted to environmental cues such as small differences or changes in water temperature, chemical composition, and the natural flow regime of natal waters (Vannote et al. 1980, Poff et al. 1997, Fausch et al. 2002), it is likely that a lower threshold of streamflow modification would be necessary to adequately protect these species. While predicted flow changes of less than 20 percent can also affect fishes and diminish stream functional capacity, EPA has not made a determination of how such smaller changes to average monthly streamflow (i.e., less than 20 percent) resulting from the 2020 Mine Plan would translate to effects on anadromous fishery areas.

Flow modeling conducted for the 2020 Mine Plan, as presented in the FEIS and outlined in Section 4.2.4.2, describes streamflow alteration in terms of percent changes to average monthly streamflows rather than percent changes to daily streamflows. EPA recognizes that daily flows would be more variable than monthly averages (e.g., Appendix B: Figure B-1); however, EPA believes that average monthly flows are a useful hydrologic metric (Eng et al. 2017, George et al. 2021), particularly for relative comparison between alternatives, and that the extent of impacts identified on a monthly time scale provides a reasonable minimum approximation of the extent of impacts from the 2020 Mine Plan, given the amount of error that can be associated with estimations of daily flows generated by models.[70] In addition, the streamflow impact information provided in the FEIS has been subject to public review. EPA recognizes using average monthly streamflows to identify the extent of impacts may under-represent and under-predict the true extent of unacceptable adverse effects, because relying on average monthly streamflows does not reflect streamflow changes that anadromous fishes and their habitats would experience on a daily or sub-daily basis (Appendix B: Sections B.2.1 and B.3.2). As a result, use of average monthly streamflow provides a broad, generalized indicator of streamflow changes that

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[70] USACE did not present or analyze daily flow information in the FEIS. Impacts of predicted changes to fish habitat were run on a daily time step (PLP 2019c: RFI 149), but the daily discharges used in that analysis were estimated from the monthly flows. RFI 161 provides daily streamflow estimates that could be used to evaluate project impacts on daily flows (PLP 2020d: RFI 161), but this information was not subject to public review prior to its release. Questions remain regarding the methods, assumptions, and limitations of the daily streamflow estimates provided in RFI 161 (PLP 2020d: RFI 161).

captures only dramatic changes from natural conditions, particularly when coupled with the narrowed focus on changes in excess of 20 percent.

To evaluate the adverse effects on anadromous fish streams that would result from the construction and routine operation of a mine at the Pebble deposit, EPA first summarizes water management processes of the 2020 Mine Plan in Section 4.2.4.2. This overview explains how the construction and routine operation of a mine at the Pebble deposit would result in streamflow increases and reductions, both of which can have adverse effects on anadromous fishery areas.

Section 4.2.4.3 then identifies the anadromous fish streams where streamflow changes would be persistent and large enough to result in a shift in the average monthly streamflow of more than 20 percent, which is where adverse effects from streamflow changes would occur under the 2020 Mine Plan. Section 4.2.4.4 characterizes the specific ways anadromous fishes use these streams, including identifying spawning and rearing areas for different anadromous fish species.

Section 4.2.4.5 summarizes adverse effects to anadromous fish habitat that would result from streamflow changes greater than 20 percent of average monthly streamflow, which are estimated to occur in at least 29 miles (46.7 km) of anadromous fish streams as a result of discharges of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan. Although not a basis for EPA's unacceptable adverse effects determination, Section 4.2.4.6 discusses how these streamflow changes would impact other fish species, because the anadromous fish streams that that would be degraded by these streamflow changes also provide habitat for non-anadromous fish species. Section 4.2.4.7 presents conclusions regarding the adverse effects of these streamflow changes on anadromous fishery areas.

4.2.4.2 Overview of Mine Site Operations that Affect Downstream Streamflow

This section summarizes water management processes of the 2020 Mine Plan to explain how the construction and routine operation of a mine at the Pebble deposit would result in streamflow increases and reductions downstream of the mine site. The FEIS describes how the 2020 Mine Plan would change the volume, distribution, and flowpath of surface water and groundwater flows in and beyond the mine footprint (USACE 2020a: Sections 4.16 and 4.17). It describes how construction and routine operation of the 2020 Mine Plan would affect surface water quantity and distribution in the SFK, NFK, UTC, and several tributaries. Operational impacts of mining on streamflow were estimated based on the conditions expected at the end of operations (i.e., end-of-mine) rather than at periodic time steps during operations (USACE 2020a: Section 4.16). Table 4-4 provides estimated percent changes in average monthly streamflows, by river reach, between baseline and end-of-mine.[71]

[71] River reaches are lettered in the upstream direction (i.e., Reach A is the most downstream reach, located just above the confluence of the SFK and NFK; Reach B is the reach upstream of Reach A; and so forth). The reaches located closest to the mine site components are NFK Trib 1.19, NFK Reach D, SFK Reach E, SFK Trib 1.19, SFK Trib 1.24, and UTC Reach F.

Dewatering of the pit area would be necessary during construction and operation, beginning approximately 2 years before the start of ore processing. The groundwater drawdown associated with dewatering the open pit would be responsible for much of the predicted streamflow reduction, along with the collection and rerouting of surface water runoff from the mine site footprint.

During operation, two WTPs would treat water collected within the mine site footprint prior to its release to the environment (Figure 4-1). WTP #1 would treat surplus groundwater and surface water runoff collected in the open pit and the surrounding areas. WTP #2 would collect and treat water from the main WMP, which would receive water from the TSFs and the TSF main embankment seepage. Treated water from the WTPs would be routed to three outfall locations and then discharged into the SFK, NFK, and UTC.[72] In an average year, mean monthly discharges to the SFK, NFK, and UTC would vary between 1.3 to 10 cubic feet per second (cfs), 17 to 27 cfs, and 0.2 to 1.4 cfs, respectively (Knight Piésold 2019a: Table 2).

Although operations would change the availability of surface flows to area streams, surplus-treated water would be released from the mine site to benefit priority fish species and life stages (USACE 2020a: Section 4.24). Monthly habitat flow needs were identified for each month of the year in the SFK, NFK, and UTC, based on priority species and life stages. In the SFK and NFK, the priority species used to determine habitat flow needs were Chinook Salmon, Coho Salmon, Rainbow Trout, and Arctic Grayling; these same species were used to determine habitat flow needs in UTC, except Sockeye Salmon replaced Chinook Salmon. In terms of life stage priorities for flow optimization, the spawning life stage was given a higher priority than juvenile rearing (PLP 2018b: RFI 048). The incubation life stage was not considered for any fish species, resulting in a lack of analysis of flow requirements for this sensitive development stage in all three watersheds.

The FEIS indicates water from both WTPs would be strategically discharged, based on modeling and monitoring during discharge. However, the streamflow monitoring proposed by PLP would occur on a quarterly basis (PLP 2019b: RFI 135).[73] WTP discharges, thus, would be preplanned and would vary on a monthly basis based on modeling and a set of assumptions. WTP discharges would be the amount identified to "optimize" downstream habitat assuming the historic monthly average streamflow (i.e., given an "average climatic year," or 50 percent exceedance probability) was to occur at the representative downstream gage location.[74]

[72] These locations are shown in FEIS Figure 4.18-1 (Knight Piésold 2019b, USACE 2020a: Section 4.18).

[73] The Monitoring Summary provided by PLP states that monitoring of surface water flow and quality is proposed to be conducted downstream of water discharge points on a quarterly basis and will focus on streamflow and fish presence surveys (PLP 2019b: RFI 135).

[74] Wet, average, and dry years were determined for each target species and life stage between 1942 and 2017 at Gage NK100A (USGS Gage 15302250) for WTP #1 and Gage SK100B (USGS Gage 1530220) for WTP #2. (PLP 2018b: RFI 048).

Table 4-4. Change in average monthly streamflow between baseline and end-of-mine with water treatment plant discharge, 2020 Mine Plan. FEIS Table 4.16-3 (USACE 2020a).

Location	Change in Average Monthly Streamflow from Baseline to End of Mine in Percent (50th Percentile Probability)												Annual Mean Monthly Change
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
NFK, Reach A	+2.2	+10.6	+19.1	+23.5	-6.2	-12.1	-8.7	-9.2	-8.0	-7.2	-3.5	-3.3	-0.2
NFK, Reach B	+2.9	+11.6	+21.5	+29.0	-9.0	-13.5	-9.5	-10.2	-9.1	-8.1	-3.2	-3.4	-0.1
NFK, Reach C	+8.2	+29.0	+68.1	+110.2	-13.3	-20.4	-15.6	-16.4	-13.9	-13.4	-6.3	-5.4	+9.2
NFK, Reach D	+101.2	+127.9	+157.6	+170.0	+26.9	+23.1	+44.2	+46.1	+36.1	+34.3	+44.4	+73.2	+73.7
NFK, Trib 1.19	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
SFK, Reach A	-2.7	-2.7	-2.1	-0.8	-1.4	-1.6	-2.8	-2.4	-2.3	-2.5	-2.3	-2.7	-2.2
SFK, Reach B	-2.2	-1.7	-0.5	+1.3	-2.4	-2.6	-3.3	-3.0	-3.2	-2.7	-2.5	-2.4	-2.1
SFK, Reach C	+3.8	0.0	0.0	0.0	-2.5	-2.8	-4.5	-3.9	-4.6	-3.1	-1.5	-1.2	-1.7
SFK, Reach D	+14.6	+27.5	+50.9	+109.0	-13.5	-15.0	-12.9	-11.9	-12.5	-10.2	+3.7	+9.3	+11.6
SFK, Reach E	-50.7	-51.5	-53.0	-52.2	-32.1	-33.1	-34.6	-37.4	-35.6	-38.8	-44.9	-49.4	-42.8
SFK, Trib 1.19	-13.4	-15.2	-17.1	-19.0	-3.7	-4.8	-7.2	-6.6	-5.3	-8.1	-10.6	-12.6	-10.3
SFK, Trib 1.24	+18.4	+97.9	0.0	+2.2	+2.7	+7.7	+11.0	+5.8	+4.8	+4.0	+7.0	+7.3	+14.1
UTC, Reach A	+0.4	+0.5	+0.7	+0.8	0.0	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.2	+0.2
UTC, Reach B	+0.4	+0.5	+0.6	+0.7	0.0	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.2	+0.2
UTC, Reach C	+0.5	+0.7	+0.8	+0.9	+0.1	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.3	+0.2
UTC, Reach D	+0.8	+1.1	+1.3	+1.7	+0.1	-0.2	-0.3	0.0	0.0	-0.2	+0.1	+0.4	+0.4
UTC, Reach E	+1.2	+1.9	+2.5	+3.2	+0.1	-0.2	-0.4	-0.1	-0.1	-0.2	+0.1	+0.6	+0.7
UTC, Reach F	+3.8	+5.5	+6.8	+8.6	+0.4	-0.8	-1.3	-0.2	-0.2	-0.7	+0.3	+1.9	+2.0
UTC, Trib 1.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

EPA has concerns with the methods used to identify the "optimal" WTP discharges and predict impacts of streamflow changes on downstream anadromous fish habitat as presented in the FEIS (Appendix B: Sections B.3 and B.4). However, as described previously, the modelled streamflow changes provided in the FEIS provides a reasonable minimum approximation of impacts for this project.

4.2.4.3 Extent of Streamflow Changes in Downstream Anadromous Fish Streams

This section identifies the specific anadromous fish streams that would be subject to streamflow changes greater than 20 percent of average monthly streamflow under the 2020 Mine Plan, which would occur in at least 29 miles (46.7 km) of anadromous fish streams. The FEIS predicts changes in streamflow downstream of the mine site to the confluence of the SFK and NFK, with and without the addition of treated water.[75] These modeling results indicate that reaches of the SFK and NFK closest to the mine site would experience greater changes in average monthly streamflow than reaches farther from the mine site (USACE 2020a: Section 4.16). The FEIS states:

> The duration of impacts to surface water hydrology would vary from temporary to permanent. The geographic extent of the impact on the NFK and the SFK rivers may extend just below the confluence of the two rivers. After the flows combine at the confluence of the NFK and SFK rivers, discernable changes in flow would be unlikely and are expected to be within historic and seasonal variation in the Koktuli River. (USACE 2020a: Page 4.16-2)

The NFK flows approximately 23 miles downstream from the mine site before reaching the SFK confluence, and the SFK extends approximately 38 miles downstream from the mine site before reaching the NFK confluence. Thus, the FEIS indicates streamflow changes would become indiscernible from historic and seasonal variation of streamflow once the NFK and SFK combine in the Koktuli River, suggesting a combined 61 miles of anadromous fish habitat in these two rivers may experience streamflow changes outside the historic and seasonal variation that naturally occurs.[76]

Based on information presented in the FEIS, EPA has estimated that operation of the 2020 Mine Plan, with the addition of treated water, would result in changes (i.e., either increase or decrease) in streamflows of more than 20 percent from baseline average monthly flow in at least 29 miles (46.7 km) of anadromous fish streams downstream of the mine site (Figure 4-9, Table 4-5).[77] These streamflow

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[75] EPA's review only evaluated changes to streamflow with the addition of treated water because regular water discharges would be necessary due to limited water storage capacity. If WTPs were unable to discharge treated water for any period, streamflow reductions experienced in downstream anadromous fish streams would be greater than are discussed herein (USACE 2020a: Section 4.16).

[76] The FEIS indicates streamflow in the UTC would not be negatively impacted by the project (USACE 2020a: Section 4.24).

[77] The streamflow alteration values presented in FEIS Table 4.16-3 (Table 4-4 here) were estimated using data from specific PLP stream gages or by averaging two gages in the reach (PLP 2019a: RFI 109f). To provide conservative estimates of changes to streamflow (i.e., to minimize the chance of overestimating streamflow changes), streamflow estimates described herein for the mainstem rivers were assigned to the river location of gages identified in RFI 109f (PLP 2019a: RFI 109f), rather than for extended reach lengths downstream. Streamflow

changes are derived from Table 4-4 (USACE 2020a: Table 4.16-3), which presents changes in average monthly streamflow, relative to natural streamflow conditions, that would result after water captured at the mine site is discharged as treated water from the WTPs. These streamflow changes would affect 18.7 miles (30.1 km), or 29 percent of anadromous fish streams, in the NFK watershed and approximately 10.4 miles (16.7 km), or 17 percent of anadromous fish streams, in the SFK watershed (Figure 4-9) (Giefer and Graziano 2022).

In the majority of the SFK and NFK reaches, streamflow changes would vary seasonally. Reaches that would experience streamflow reductions between spring and winter would also experience streamflow increases between winter and spring. In total, streamflow reductions exceeding 20 percent of average monthly streamflow would occur in at least one month per year in at least 13.1 miles (21.4 km) of anadromous fish streams downstream of the mine site, specifically in NFK Reach C, Tributaries NFK 1.190 and 1.200, and SFK above Frying Pan Lake (i.e., upstream of SK100G) (Table 4-5).

Additionally, WTP discharges associated with the 2020 Mine Plan would increase streamflow by more than 20 percent of baseline average monthly streamflow in at least 25.7 miles (41.3 km) of downstream anadromous fish streams (Table 4-5). Most streamflow increases would occur in the mainstem NFK, where at least 18.1 miles (29.1 km) would experience seasonal streamflow increases of more than 20 percent of baseline average monthly flow. The remaining 7.6 miles (12.2 km) of anadromous fish streams that would experience streamflow increases of more than 20 percent from baseline average monthly flows are in the SFK watershed, in the mainstem at Frying Pan Lake and in Tributary SFK 1.240.

4.2.4.4 Downstream Anadromous Fish Habitats Affected by Streamflow Changes

This section identifies the specific anadromous fish habitat that would be subject to streamflow changes greater than 20 percent of average monthly streamflow under the 2020 Mine Plan, which would occur in at least 29 miles (46.7 km) of anadromous fish streams. Changes in surface water and groundwater contributions to streams associated with the discharge of dredged and fill material for the construction and routine operation of the 2020 Mine Plan would reduce both the extent and quality of anadromous fish habitats downstream of the mine site. As described in Section 4.2.1, little or no spawning or rearing habitat for Coho and Chinook salmon would remain in Tributary NFK 1.190 due to placement of mine site features just upstream of its confluence with the mainstem NFK; most of Tributary NFK 1.200 also would be eliminated by the main WMP (Figure 4-9). The FEIS states that the expected loss of headwater aquatic habitats would affect downstream surface water flows and groundwater exchange, resulting in impacts to aquatic resources in approximately 66 miles (106.2 km) of streams. The duration of streamflow changes would be permanent, beginning at project construction, continuing through mine operations, and remaining post-closure (USACE 2020a: Section 4.24).

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change estimates were assumed to extend upstream from the source gage to at least the next gage, major confluence point, the mine footprint, or the most upstream extent of anadromous habitat. As a result, streamflow changes may extend further downstream than estimated herein.

Figure 4-9. Streams and rivers with documented salmon use that would experience streamflow alterations greater than 20 percent of baseline average monthly streamflows as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).

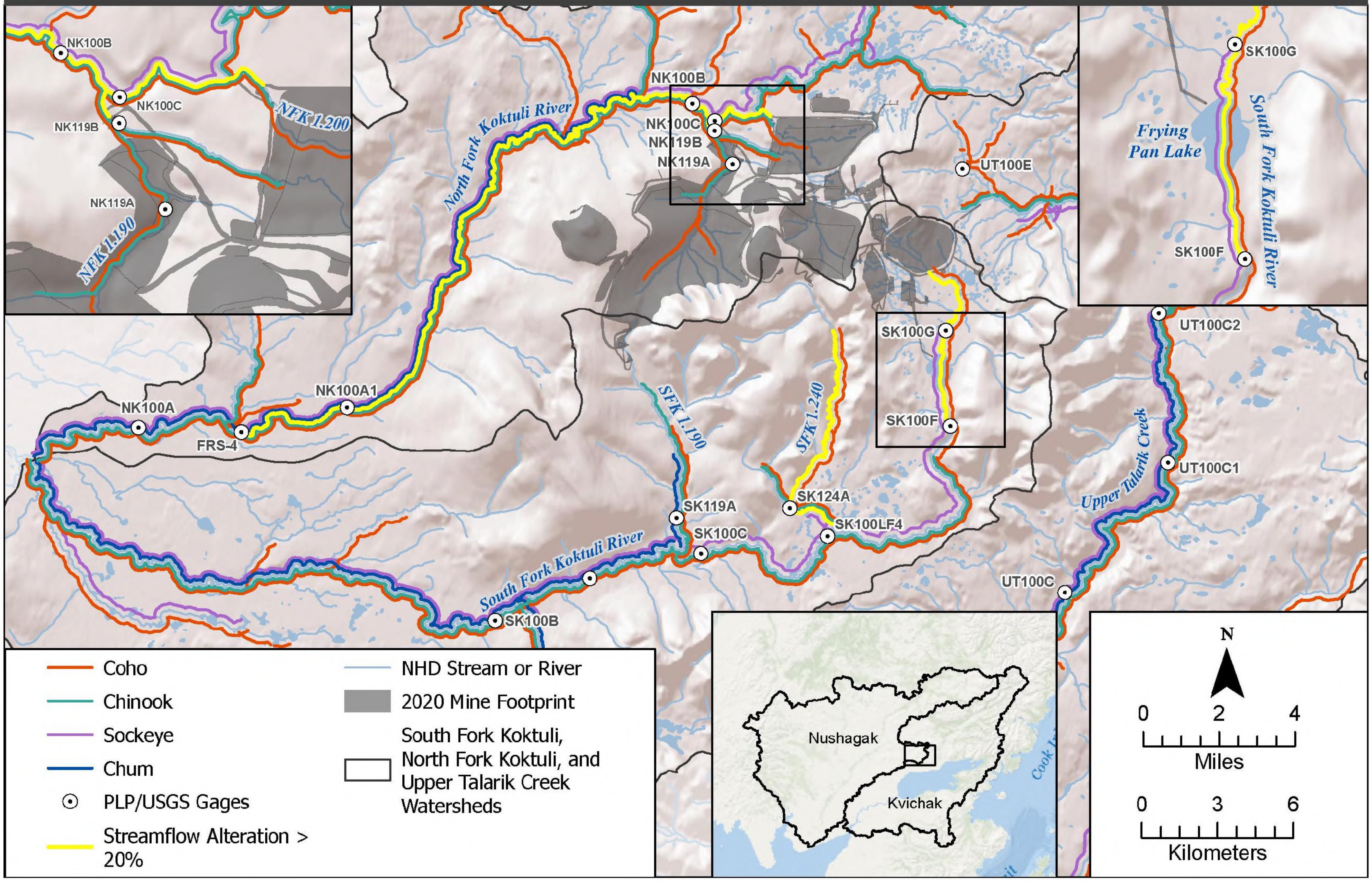

Table 4-5. Salmon species documented to occur in downstream reaches that would experience greater than 20 percent streamflow alterations under the Pebble 2020 Mine Plan.

Stream	Reach [a]	Affected Stream Length (miles) [b]	Information from FEIS Table 4.16-3 (USACE 2020a)		Salmon Species and Life Stages Present [c]			
			Location	Largest Change in Monthly Average Streamflow	Coho	Chinook	Sockeye	Chum
SFK mainstem	Upstream of SK100G	2.1	SFK, Reach E	-53.0%	Rearing	-[g]	-[g]	-[g]
	SK100G to inlet of Frying Pan Lake	0.7			Rearing	-[g]	Rearing [h]	-[g]
	Frying Pan Lake to SK100F	1.4	SFK, Reach D	109.0%	Rearing	-[g]	Rearing	-[g]
SFK tributary	SFK 1.240	6.2[d]	SFK, Trib 1.24	97.9%	Rearing, present	Present	Rearing	-[g]
NFK tributaries	NFK 1.190	0.27[e]	NFK, Trib 1.19	-100.0%	Spawning, rearing	Rearing	-[g]	-[g]
	NFK 1.200	0.36[e]	NFK, Trib 1.20	-[f]	Rearing, present	Rearing	-[g]	-[g]
NFK mainstem	NFK below Tributary 1.200 and above Tributary 1.190	1.2	NFK, Reach D	170.0%	Spawning, rearing	Rearing	Spawning	-[g]
	NFK below Tributary 1.190 to FRS-4	9.6	NFK, Reach C	110.2%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning, rearing
		4.6	NFK, Reach B	29.0%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning
		2.7	NFK, Reach A	23.5%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning

Notes:

a Reaches defined by stream gages, as shown in Figure 4-9.

b Affected lengths were determined by EPA based on information in the FEIS and typically extend upstream from the source gage to at least the end of the FEIS reach, the next upstream gage, major confluence point, the mine footprint, or the end of documented anadromous fish streams.

c From the Anadromous Waters Catalog (Giefer and Graziano 2022).

d This length includes the entirety of Tributary SFK 1.240 down to its confluence with Tributary SFK 1.260.

e This length is the extent that is assumed would still be accessible to anadromous fishes below the sediment pond.

f No streamflow information was provided for this reach in FEIS Table 4.16-3 (Table 4-4).

g Blanks indicate that the species has not been documented to occur in that reach in the Anadromous Waters Catalog (Giefer and Graziano 2022).

h Sockeye Salmon rearing habitat only extends approximately 0.6 mile upstream of Frying Pan Lake and not all the way up to SK100G (Giefer and Graziano 2022).

The most notable streamflow reductions downstream of the mine site would occur in the 2.8-mile (3.4-km) reach of anadromous fish habitat in the SFK mainstem leading to Frying Pan Lake, immediately below the open pit drawdown zone. Average monthly streamflow in this reach would be reduced by 32 to 53 percent from the baseline average monthly streamflow in every month of the year (Tables 4-4 and 4-5). This reach provides juvenile rearing habitat for Coho Salmon, and the lowermost 0.6 mile above the lake provides juvenile rearing habitat for Sockeye Salmon (Giefer and Graziano 2022).

As a result of dewatering at the pit, streamflow reductions in the SFK would reduce natural inflows to Frying Pan Lake, a 150-acre (0.6-km^2) shallow lake located on the SFK, 2.5 miles (4.0 km) downstream of the open pit (Figure 4-1). Frying Pan Lake provides rearing habitat for juvenile Coho and Sockeye salmon, as well as other resident fishes (ADF&G 2022a). As previously discussed, WTP discharges directly into Frying Pan Lake would be used to mitigate these streamflow reductions. Even with such WTP discharges, there would still be net reductions in streamflow between May and October, when streamflow at gage SK100F is estimated to be reduced by 10.2 to 15 percent below the baseline average monthly flow. During the winter and spring, WTP discharges would go beyond offsetting streamflow reductions and result in significant streamflow increases: average monthly streamflow would increase 27.5 percent over the baseline average monthly streamflow in February, 50.9 percent over baseline in March, and 109 percent over baseline in April (Figure 4-9, Table 4-4). Sustaining such increases above the natural flow regime for months at a time could have significant adverse effects on aquatic resources in this reach of the SFK.

These impacts to streamflow in the SFK would continue some distance downstream of gage SK100F, but it is unclear how far due to a lack of detail in the data used in FEIS (USACE 2020a: Section 4.16). The next downstream location for which streamflow data are presented in Table 4-4 (FEIS Table 4.16-3) is SFK Reach C, which is based on streamflow at gage SK100C (PLP 2019a: RFI 109f). Gage SK100C is located 11.7 river miles (18.9 km) downstream of gage SK100F (PLP 2020d: RFI 161), and streamflow changes in the SFK at gage SK100C resulting from operations at the mine would be less than 5 percent below baseline average monthly flow, assuming streamflow and WTP discharges occurred as modeled for the average climatic year.

Reductions in streamflow would also affect 5.1 miles (8.2 km) of anadromous fish spawning and rearing habitat in Tributary SFK 1.190 (USACE 2020a: Section 4.24), due to water captured in the south seepage recycle pond and returned to the bulk TSF main seepage pond (Figure 4-1) (USACE 2020a: Section 4.16). Tributary SFK 1.190 would experience streamflow reductions every winter and spring ranging between approximately 12.6 percent (in December) to the maximum reduction of 19 percent (in April) below the baseline average monthly streamflow (Table 4-4).[78]

Streamflow estimates for Tributary SFK 1.190 were generated based on streamflow gage SK119A (PLP 2019a: RFI 109f), which is located approximately 3 miles (4.8 km) downstream of mine footprint components associated with the south embankment of the bulk TSF, including a seepage collection system and sediment pond. The upper reaches of Tributary SFK 1.190 closest to the mine are expected to experience even greater reductions in streamflow compared to those estimated at streamflow gage SK119A. The upper extent of anadromous fish habitat is Chinook Salmon rearing habitat, located within approximately 600 feet (182.9 m) of the mine footprint. Coho Salmon also use this tributary for rearing beginning approximately 1.3 miles (2.1 km) downstream of the mine footprint, and Chum Salmon are

[78] Because the modelled streamflow changes in SFK Tributary 1.190 do not equal or exceed 20 percent of baseline average monthly streamflow, EPA has not included this tributary in the 29 miles of anadromous fish habitat that would experience streamflow changes greater than 20 percent. Yet, the FEIS disclosed adverse effects of the 2020 Mine Plan on anadromous fish habitat in SFK Tributary 1.190 are noteworthy in these discussion of adverse effects.

present approximately 1.8 miles (2.9 km) downstream of the mine footprint (Giefer and Graziano 2022). Although streamflow reductions in Tributary SFK 1.190 are estimated to reach only 19 percent below baseline average monthly streamflow, the FEIS predicts these reductions would nonetheless result in losses of spawning habitat area in Tributary SFK 1.190, eliminating 18.1, 13, 5.9, and 8.6 percent of spawning habitat for Chinook, Coho, Chum, and Sockeye salmon, respectively, in Tributary SFK 1.190 during an average climatic year (USACE 2020a: Table K4.24-1).[79]

Streamflow reductions would also be expected in mainstem reaches of the SFK and NFK during spring, summer, and fall. In total, approximately 21.4 miles (34.4 km) of the SFK and NFK would experience some degree of streamflow reduction from baseline conditions between May through late fall or winter due to loss of headwater and groundwater contributions. These reaches would also experience seasonal increases from baseline average monthly streamflow between January and April due to discharges of surplus water. For example, average monthly streamflow in the mainstem NFK below the mine site (i.e., NFK Reach C) would vary from 110.2 percent more flow in April to 20.4 percent less in June relative to baseline average monthly streamflows (Table 4-4).

Streamflow reductions in the NFK would extend 16.9 miles (27.2 km) downstream of the mine site. These reductions would begin in NFK Reach C below the confluence with Tributary NFK 1.190 (Figure 4-9), where streamflow would be reduced by more than 20 percent from the baseline average monthly flow. Streamflow reductions would continue downstream to at least stream gage FRS-4, where streamflow is estimated to be reduced by 12 to 13 percent from the baseline average monthly flow (Tables 4-4 and 4-5, Figure 4-9). These NFK reaches provide spawning and rearing habitat for Chinook, Coho, Sockeye, and Chum salmon (Table 4-5, Figure 4-9) and these streamflow reductions would affect at least 26 percent of the documented anadromous fish streams in the NFK watershed (Giefer and Graziano 2022). The FEIS predicts a loss of Chinook Salmon spawning habitat in all NFK reaches downstream of the mine site: 9.9 percent in NFK Reach C, 3.3 percent in NFK Reach B, and 1.8 percent in NFK Reach A (USACE 2020a: Table K4.24-1).[80]

Even with treated water discharges included in these estimates, streamflows in the SFK and NFK watersheds would still be reduced by more than 20 percent from the baseline average monthly flow in at least one month of the year in approximately 13.1 miles of anadromous fish streams, specifically in NFK Reach C, Tributaries NFK 1.190 and 1.200, and SFK above Frying Pan Lake (i.e., upstream of SK100G) (Table 4-5, Figure 4-9).

Operation of the 2020 Mine Plan would also increase streamflow by more than 20 percent of baseline average monthly streamflow in at least 25.7 miles (41.3 km) of anadromous fish streams due to WTP discharges (Table 4-5). Most streamflow increases would occur in the mainstem NFK, where at least 18.1 miles (29.1 km) would seasonally experience streamflow increases of more than 20 percent of

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[79] Habitat losses described in the FEIS likely under-represent impacts on downstream anadromous fish streams (Appendix B: Sections B.3 and B.4).

[80] Habitat losses described in the FEIS likely under-represent impacts on downstream anadromous habitat area (Appendix B: Sections B.3 and B.4).

baseline average monthly flow. These 18.1 miles (29.1 km) include the 16.9 miles (27.2 km) of the mainstem NFK (i.e., down to gage FRS-4) that would also experience some degree of streamflow reduction between May and December, and the remaining 1.2 miles (1.9 km) of the NFK between the confluence of Tributaries NFK 1.200 and 1.190, where WTP discharges would result in year-round increases in flow.

The remaining 7.6 miles (12.2 km) of anadromous fish streams that would experience streamflow increases of more than 20 percent from baseline average monthly flow are the SFK between SK100G and SK100F and Tributary SFK 1.240 (Table 4-5, Figure 4-9). Increases in the SFK would result from WTP discharges to Frying Pan Lake, as well as discharges from a diversion channel of non-contact water collected around the mine site infrastructure to Tributary SFK 1.240 (Knight Piésold 2019b).

To optimize fish habitat farther downstream, reaches closest to the WTP discharge points would experience more dramatic increases in streamflow velocities that could impede salmon migration, particularly for juveniles. For example, NFK Reach D, immediately downstream of the WTP discharge point, would experience streamflow increases of 101 to 170 percent from baseline average monthly flow every month between January and April (Table 4-4). This reach provides spawning habitat for Coho and Sockeye salmon, and rearing habitat for juvenile Coho and Chinook salmon (Giefer and Graziano 2022). Habitat quality for juvenile salmon rearing and benthic macroinvertebrates would likely be degraded due to increased scour and mobilization of sediments and increased turbidity. Streamflow increases would be expected to dissipate farther downstream from the mine site, but streamflows at even the most downstream NFK point evaluated (i.e., PLP's project-specific stream gage FRS-4, which was used to estimate streamflow in NFK Reach A) would vary from 23.5 percent more to 12.1 percent less than the baseline average monthly streamflow (Table 4-4). Based on information in the FEIS, these streamflow increases would likely extend downstream to the confluence of the SFK and NFK (USACE 2020a: Section 4.16).

4.2.4.5 Adverse Effects of Streamflow Changes in Downstream Anadromous Fish Streams

This section summarizes the adverse effects to anadromous fish habitat that would occur as a result of streamflow changes that are greater than 20 percent of average monthly streamflow, which would occur in at least 29 miles (46.7 km) of anadromous fish streams as a result of discharge of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan. These streamflow changes include either increases or decreases relative to baseline average monthly streamflows (Table 4-4). Streamflow reductions would result from groundwater drawdown due to pit dewatering, the loss of upstream tributaries, and the collection and rerouting of surface water runoff from the mine site, particularly between spring and winter (USACE 2020a: Sections 4.16 and 4.17). Streamflow increases would occur between winter and spring as a result of WTP discharges and discharges of surface water runoff captured at the mine site. Both streamflow increases and streamflow reductions that are greater than 20 percent of baseline average monthly streamflow can have adverse effects on anadromous fishery areas. These adverse effects on anadromous fishery areas would result from any mine at the Pebble deposit if such streamflow changes greater than 20 percent average

monthly flow were expected to occur over such a large extent [29 miles (46.7 km)] of anadromous fish streams.

Streamflow reductions of the extent and duration predicted by analysis of streamflow data in the FEIS would reduce instream habitat availability, particularly during periods of natural low flows; fragment stream habitats; and preclude normal seasonal movements by anadromous and migratory resident fishes (West et al. 1992, Cunjak 1996, EPA 2014: Chapter 7). Diminished streamflows would also likely reduce the frequency and duration of connectivity to off-channel habitats such as side channels, riparian wetlands, and beaver ponds, reducing the spatial extent of such habitats or eliminating them altogether. At present, some off-channel habitats likely connect to the main channels at least during annual spring and fall floods (Section 3.2.4). The loss of access to off-channel areas, particularly those with groundwater connectivity, would remove critical rearing habitats for several species of juvenile salmonids (Table 3-10) (Quinn 2018, Huntsman and Falke 2019).

Reduced streamflows would also likely change sediment transport dynamics, resulting in the deposition of more or finer sediment that would smother eggs or render stream substrates less suitable for spawning. Streambed aggradation from increased sedimentation could lead to further hydrologic modification, loss of habitat complexity, simplification of pools important for rearing salmon, and outright loss or fragmentation of habitat. Lower streamflows could also result in reduced dissolved oxygen levels. Taken together, streamflow changes would likely alter channel geometry and destabilize channel structure, with effects propagating downstream.

The interaction between surface and groundwater has been shown to strongly influence the structure, function, and biodiversity of aquatic communities (Woody and Higman 2011). Groundwater drawdown due to pit dewatering would reduce the volume of groundwater available to surface waters and wetlands surrounding the mine site (USACE 2020a: Section 4.17). This loss of groundwater contributions to surface waters would have significant repercussions for fishes, as groundwater is known to play an important role in redd site selection by Pacific salmon by sustaining stream baseflows (preventing redds from drying or freezing), providing stable temperatures, and supplying nutrients (Bjornn and Reiser 1991, Anderson and Bromaghin 2009, Curran et al. 2011, Mouw et al. 2014, McCracken 2021). The FEIS indicates that salmon spawning aggregations in both the SFK and NFK are associated with areas of groundwater discharge. Predicted changes in groundwater flows could result in impacts to salmonid egg incubation, juvenile salmon imprinting and rearing, and adult salmon natal homing. These changes in habitat function could reduce fish productivity in the Koktuli River watershed (USACE 2020a: Page 4.24-19).

At the other extreme, streamflow increases greater than 20 percent likely would degrade habitat suitability for salmon (EPA 2014: Chapter 7). Brekkan et al. (2022: Page 8) conclude that the stream type at the mainstem SFK, NFK, and UTC immediately downstream of the mine site is “very susceptible to scour and erosion and can be significantly altered and rapidly de-stabilized by channel or landscape disturbances and changes in the flow or sediment regimes of the contributing watershed.” As result, increases in streamflow could increase mobilization of sediments, leading to altered spawning gravel

quality, reduced survival of salmon eggs that are scoured or buried (Buffington et al. 2004), or reduced foraging efficiency of juvenile salmon (Bjornn and Reiser 1991). Increased streamflows could also eliminate off-channel habitat through the erosion of streambanks, and could reduce invertebrate populations as a result of streambed scour and erosion.

As previously discussed, proposed water management under the 2020 Mine Plan uses treated discharges to offset some of the streamflow reductions and address stream habitat losses. According to the FEIS, treated water releases would be discharged in direct proportion to the water captured from each of the three watersheds in the mine footprint area, and discharges would be "optimized to benefit priority fish species and life-stages for each month and stream" (USACE 2020a: Page 4.24-12). However, the complexity inherent in surface water–groundwater interactions in the SFK, NFK, and UTC watersheds makes it difficult to predict, regulate, and control such interactions when large-scale human alteration of the landscape occurs (Hancock 2002). Discharges of treated water will not replicate natural surface water–groundwater interactions, which will have already been significantly altered by reductions in groundwater and surface water flows to downgradient habitats. Adequately protecting the critical services that groundwater provides to fishes, via its influence on surface waters, is complicated by the fact that groundwater flow paths vary at multiple scales and connections between distant recharge areas and local groundwater discharge areas are difficult to predict (Power et al. 1999).

The reduction of downgradient groundwater and surface water flows and resulting changes in surface water–groundwater interactions also will affect water temperatures in downstream anadromous reaches, further impacting salmon populations. Winter streamflow and water temperature are both predicted to increase in the NFK as a result of the 2020 Mine Plan and would continue to be increased through April each year (USACE 2020a: Sections 4.18 and 4.16).[81] The threshold between completely frozen and partially frozen streams can be a narrow one (Irons et al. 1989), especially for small streams with low winter groundwater inputs (i.e., like many of the headwater streams in the SFK, NFK, and UTC watersheds). As a result, even small increases in winter water temperatures can have large effects. These predicted increases in winter streamflow and temperature would likely reduce ice cover and increase flow velocities, resulting in substantial alteration of fish habitats (Huusko et al. 2007, Brown et al. 2011) and reduced spawning success due to the scouring of redds.

Because the timing of salmon migration, spawning, and incubation are closely tied to seasonal water temperatures, any change in thermal regimes could also disrupt life history timing cues and result in mismatches between fishes and their environments, which would adversely affect survival (Angilletta et al. 2008). Streamflow reductions resulting from the loss of temperature-moderating groundwater inputs or streamflow and temperature increases resulting from WTP discharges could reduce diversity of run timing and other salmon life history traits (Hodgson and Quinn 2002, Rogers and Schindler 2011, Ruff et al. 2011), which play an important role in creating and maintaining biocomplexity (Section 3.3.3). Although fish populations may be adapted to periodic disturbances associated with natural flow

[81] The extent and duration of temperature changes would depend on the temperature, quantity, and timing of WTP discharges, as well as the influence of other inputs such as groundwater and tributary inflows.

variability (Poff et al. 1997, Matthews and Marsh-Matthews 2003), changes that disrupt life history timing cues can adversely affect survival; prolonged changes in streamflow regimes can have longer-term impacts on fish populations (Jensen and Johnsen 1999, Lytle and Poff 2004). See Appendix B (Section B.5.1) for further discussion of water quality effects on aquatic resources.

Overall, the adverse effects of streamflow changes on stream and off-channel habitats would substantially reduce spawning success for Coho Salmon, survival of overwintering Coho, Chinook, and Sockeye salmon, and ultimately productivity of Coho, Chinook, and Sockeye salmon in the SFK and NFK watersheds. Many effects of substantially changed streamflows would reverberate downstream beyond the directly affected waters due to reduced quantity and diversity of available food sources, such as macroinvertebrates and reduced success of upstream salmon spawning and rearing. Streamflow changes associated with operation of the 2020 Mine Plan also would affect many other factors that determine high-quality salmon habitat (e.g., water depth and velocity, substrate size, groundwater exchange, water temperature, food availability), although effects of streamflow on these other factors are not evaluated in the FEIS (see Appendix B).

Streamflow changes of greater than 20 percent of baseline average monthly streamflow will adversely affect and degrade downstream anadromous fish habitat (Sections 3.2.4 and 4.2.1, Figures 4-3 through 4-5). The downstream waters that would experience such streamflow changes are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 4-2 and 4-3). The large extent of these streamflow changes (29 miles [46.7 km]) would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3). The damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from these streamflow changes of more than 20 percent of baseline average monthly flow also would erode habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining the stability and productivity of these populations.

Furthermore, discharges of dredged or fill material into waters of the United States located anywhere in the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9, Table 4-4). Also, the anadromous fish streams in the SFK, NFK, and UTC watersheds support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section 3.3) (USACE 2020a: Section 3.24). If discharges of dredged or fill material placed anywhere in the mine site area resulted in 29 miles (46.7 km) of streamflow changes greater than 20 percent of baseline average monthly streamflow, then the same adverse effects to downstream anadromous fishery areas would occur as described for the 2020 Mine Plan due to the large extent of streamflow changes to downstream anadromous fishery areas that support the same anadromous fish species and life stages as those affected by the 2020 Mine Plan.

4.2.4.6 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that anadromous fish streams that would be degraded by these alterations in streamflow also provide habitat for non-anadromous fish species (Figures 4-10 and 4-11). The assemblage of non-anadromous fishes found in and supported by these streams is an important component of these habitats and further underscores the biological integrity and ecological value of these largely undeveloped watersheds with intact stream networks. The SFK mainstem that would be subject to streamflow alterations downstream from the mine provides habitat for Arctic Grayling, Northern Pike, sculpin, and stickleback. Streamflow alterations in Tributary SFK 1.190 would affect habitat for Arctic Grayling, Dolly Varden, sculpin, and stickleback. Streamflow alterations in Tributary SFK 1.240 would affect habitat for these same species plus Northern Pike (ADF&G 2022a).

In the NFK watershed, secondary effects of downstream flow alteration would affect mainstem NFK habitats for Arctic Grayling, Dolly Varden, Rainbow Trout, Round Whitefish, and sculpin. Dolly Varden, Northern Pike, and Arctic Grayling are harvested in downstream subsistence and recreational fisheries (Section 4.2.1). Thus, in addition to providing salmon habitat, streams that would be affected by streamflow alterations also provide habitat for other non-anadromous fish species important to subsistence and recreational fisheries.

Figure 4-10. Streams and rivers with occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden that would experience streamflow changes as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).

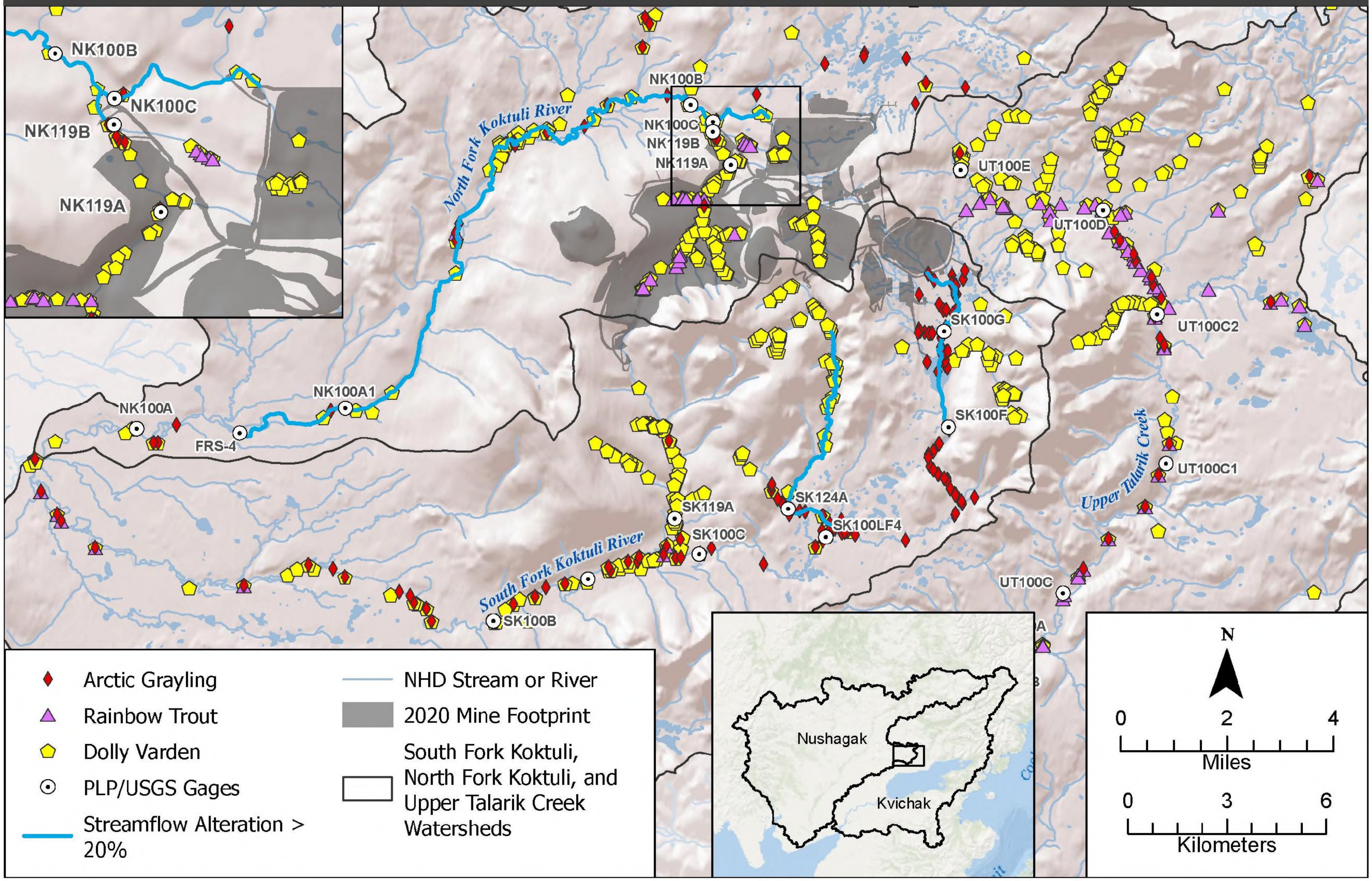
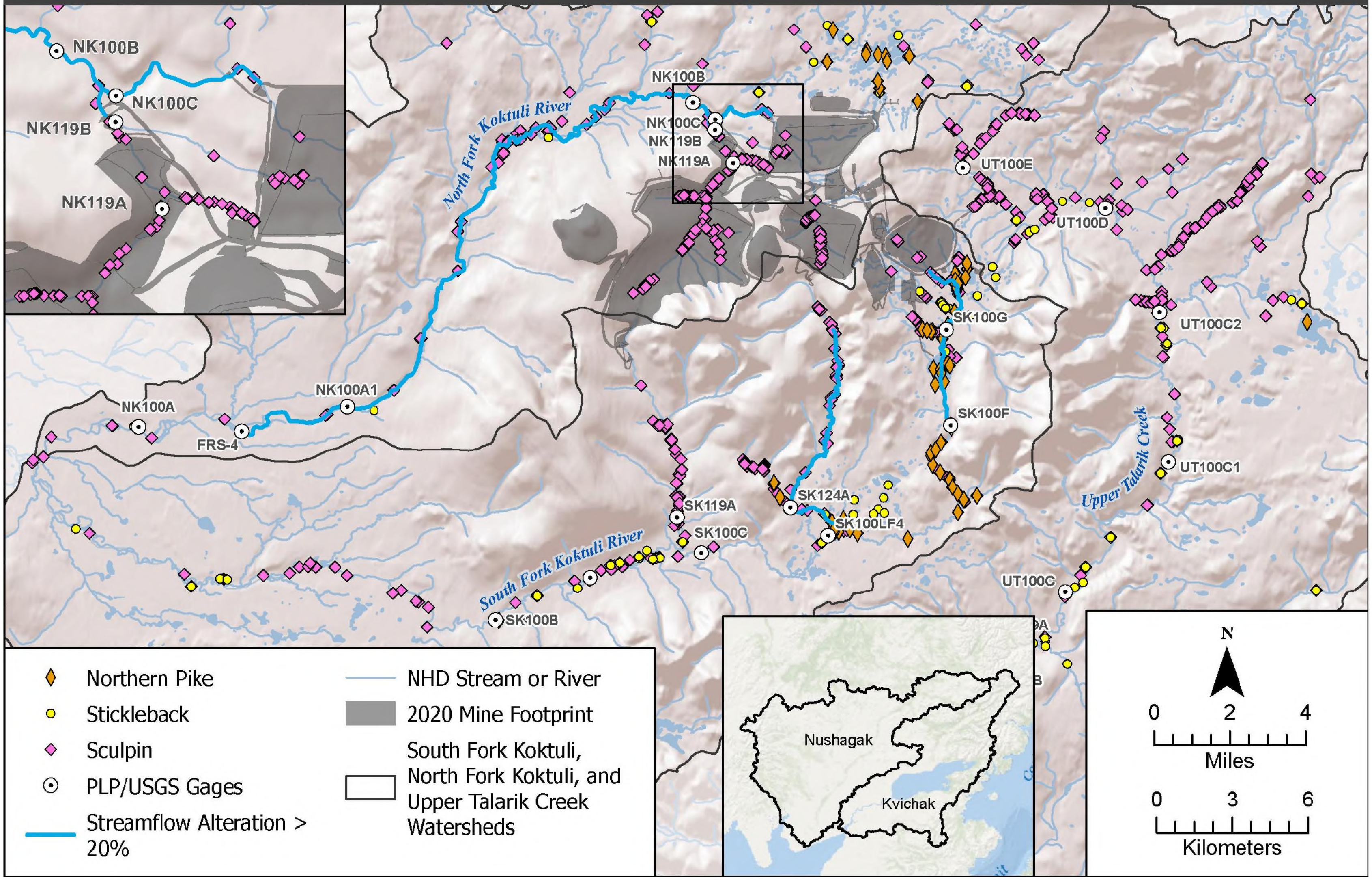


Figure 4-11. Streams and rivers with occurrence of other resident fish species that would experience streamflow changes as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).



4.2.4.7 Conclusions

EPA has considered and evaluated the information available regarding how streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, such streamflow changes will have unacceptable adverse effects on anadromous fishery areas if the discharges of dredged or fill material are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.4.7.1 Adverse Effects from Discharges of Dredged or Fill Material at the Mine Site that Result in Streamflow Changes in Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.4.1 through 4.2.4.5: the large extent and magnitude of streamflow changes in anadromous fish streams; the corresponding degradation of and thus damage to anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, resulting from these streamflow changes; and the resulting erosion of and thus damage to both habitat complexity and biocomplexity within the SFK and NFK watersheds, which are key to the abundance and stability of salmon populations within these watersheds.

Discharges of dredged or fill material anywhere in the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams downstream of the mine site that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9; Table 4-4). These anadromous fish streams support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section 3.3) (USACE 2020a: Section 3.24). Thus, the same or greater levels of streamflow changes in anadromous fish streams downstream of the mine site resulting from discharges of dredged or fill material associated with developing the Pebble deposit located anywhere in the mine site area (Figures ES-5 and 4-1) within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.4.7.2 Adverse Effects from Discharges of Dredged or Fill Material Elsewhere in the SFK, NFK, and UTC Watersheds that Result in Streamflow Changes in Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[82]

Thus, this final determination considers the effects of relocating streamflow changes greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream

[82] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and

have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

The natural flow regime is a critical component of streams and rivers and their hydrologically connected aquatic habitats because flow directly or indirectly affects all other physical, chemical, and biological components of these systems (Bunn and Arthington 2002, Lytle and Poff 2004, Poff and Zimmerman 2010, Sofi et al. 2020, Tonkin et al. 2021). The body of published scientific literature on the functional consequences of hydrograph alteration is extensive (e.g., Poff et al. 1997, Tonkin et al. 2021, Freeman et al. 2022). Streamflow changes that exceed 20 percent of average monthly streamflow would constitute a significant change in the natural hydrograph, with repercussions for the physical, chemical, and biological characteristics of both the affected reaches and downstream areas. Although fish populations may be adapted to periodic disturbances associated with natural flow variability (Poff et al. 1997, Matthews and Marsh-Matthews 2003), changes that persist disrupt life history timing cues for adult migration to natal spawning sites, spawn timing, emergency timing, and juvenile outmigration. Changes in these cues will adversely affect survival, and prolonged changes in streamflow regimes can have longer-term impacts on fish populations (Jensen and Johnsen 1999, Lytle and Poff 2004).

The 2020 Mine Plan would result in streamflow changes greater than 20 percent of average monthly streamflow in at least 29 miles of anadromous fish streams. These streamflow changes would include both streamflow reductions due to losses of headwater and groundwater contributions and streamflow increases due to WTP discharges of treated water. These streamflow alterations would vary spatially and seasonally, with areas closest to the open mine pit and WTP discharge sites experiencing the most significant streamflow changes.

As discussed in Section 4.2.4.5, WTP discharges that increase streamflow by more than 20 percent of baseline average monthly streamflow would alter channel geometry and destabilize channel structure, with effects propagating downstream. Such streamflow increases will degrade habitat suitability for salmon by increasing mobilization of sediments, leading to altered spawning gravel quality, reduced survival of salmon eggs that could be scoured or buried (Buffington et al. 2004), and reduced foraging efficiency of juvenile salmon (Bjornn and Reiser 1991). Increased streamflows could also eliminate off-channel habitats through the erosion of streambanks and could reduce invertebrate populations due to streambed scour and erosion.

Operations at the mine site would also result in streamflow reductions in anadromous fish streams due to losses of headwater and groundwater contributions. These losses would reduce instream habitat availability, particularly during periods of natural low flows; fragment stream habitats; and preclude normal seasonal movements by anadromous and migratory resident fishes (West et al. 1992, Cunjak 1996, EPA 2014: Chapter 7). Diminished streamflows would also likely reduce the frequency and

duration of connectivity to off-channel habitats such as side channels, riparian wetlands, and beaver ponds, reducing the spatial extent of such habitats or eliminating them altogether. The loss of access to off-channel areas, particularly those with groundwater connectivity, would remove critical rearing habitats for several species of juvenile salmonids (Table 3-10) (Quinn 2018, Huntsman and Falke 2019). Reduced hydrologic connectivity between streams and riparian wetlands would also likely reduce or eliminate the export of detritus, macroinvertebrates, and other ecological subsidies from wetlands and off-channel habitats to streams.

The loss of groundwater inputs combined with WTP discharges would result in increased winter streamflow and water temperature, which would have profound adverse effects on stream thermal regimes (EPA 2014: Chapter 7). These predicted increases in winter streamflow and temperature would likely reduce ice cover and increase flow velocities, resulting in substantial alteration of fish habitats (Huusko et al. 2007, Brown et al. 2011) and reduced spawning success due to the scouring of redds. Because the timing of salmon migration, spawning, and incubation are closely tied to seasonal water temperatures, any change in the thermal regime could disrupt life history timing cues and result in mismatches between fishes and their environments, which would adversely affect survival (Angilletta et al. 2008).

Overall, the adverse effects of streamflow changes greater than 20 percent of average monthly flows on stream and off-channel habitats would substantially reduce spawning success, overwinter survival, and ultimately salmon productivity in anadromous fish streams. The large extent of these streamflow changes (29 miles [46.7 km]) would adversely affect salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3) and significantly damage downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds by eroding habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining stability and productivity of these populations.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan and the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that the anadromous fish streams throughout these watersheds are

currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large extent and magnitude of streamflow changes in anadromous fish streams and the corresponding degradation of and thus damage to anadromous fish streams, including spawning and rearing habitat, resulting from these streamflow changes (Section 4.2.4.5); and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.5 Summary of Effects on Fishery Areas from Discharges of Dredged or Fill Material from Developing the Pebble Deposit

In summary, EPA has determined that certain discharges of dredged or fill material into waters of the United States for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds (Sections 4.2.1 through 4.2.4). EPA has also determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the mine site area (Figure 4-1) within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan. Further, EPA has determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds will have unacceptable adverse effects on anadromous fishery areas in these watersheds if the effects of such discharges are similar or greater in nature and magnitude to those described in Sections 4.2.1 through 4.2.4. Because of the nature and magnitude of the aquatic resource losses and streamflow changes described in Sections 4.2.1 through 4.2.4, EPA considers each "a large impact" and "one that the aquatic and wetland ecosystem cannot afford" (44 FR 58078).

4.3 Compliance with Relevant Portions of the CWA Section 404(b)(1) Guidelines

EPA has broad discretion under CWA Section 404(c) to evaluate and determine whether a discharge would result in an "unacceptable adverse effect" on fishery areas, including breeding and spawning areas. EPA has determined that certain discharges of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas, as described in Section 4.2.

EPA's CWA Section 404(c) regulations at 40 CFR 231.2(e) provide that in evaluating the "unacceptability" of effects, consideration should be given to the "relevant portions of the CWA Section

404(b)(1) Guidelines." As detailed in this section, evaluation of compliance with relevant portions of the Guidelines supports and confirms EPA's determination that discharges of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit as described in Section 4.2 will have unacceptable adverse effects on anadromous fishery areas.

For the purposes of evaluating the unacceptability of effects from discharges of dredged or fill material associated with the 2020 Mine Plan, EPA evaluated the following portions of the CWA Section 404(b)(1) Guidelines in the manner discussed in this section:

- Significant degradation of waters of the United States (40 CFR 230.10(c))
  - Cumulative effects (40 CFR 230.11(g))
  - Secondary effects (40 CFR 230.11(h))
- Minimization of adverse impacts on aquatic ecosystems (40 CFR 230.10(d))

4.3.1 Significant Degradation

The CWA Section 404(b)(1) Guidelines direct that no discharge of dredged or fill material shall be permitted if the discharge will cause or contribute to significant degradation of waters of the United States (40 CFR 230.10(c)). Of particular relevance, the Guidelines state that effects contributing to significant degradation, considered individually or collectively, include the following:

1. Significantly adverse effects of the discharge of pollutants on human health or welfare, including but not limited to effects on municipal water supplies, plankton, fish, shellfish, wildlife, and special aquatic sites;
2. Significantly adverse effects of the discharge of pollutants on life stages of aquatic life and other wildlife dependent on aquatic ecosystems, including the transfer, concentration, and spread of pollutants or their byproducts outside of the disposal site through biological, physical, and chemical processes;
3. Significantly adverse effects of the discharge of pollutants on aquatic ecosystem diversity, productivity, and stability. Such effects may include, but are not limited to, loss of fish and wildlife habitat or loss of the capacity of a wetland to assimilate nutrients, purify water, or reduce wave energy; and
4. Significantly adverse effects of discharge of pollutants on recreational, aesthetic, and economic values.

Findings of significant degradation related to proposed discharges must be based on appropriate factual determinations, evaluations, and tests, as described in 40 CFR 230.11, with special emphasis on the persistence and permanence of the effects evaluated.

EPA's regulations at 40 CFR 230.5 identify the stepwise process to assess the potential for significant degradation. The assessment of impacts pursuant to subparts C through F (40 CFR 230.20–230.54) informs the required factual determinations found in 40 CFR 230.11. The factual determinations, in turn, inform the significant degradation finding and the finding of compliance or non-compliance with the

Guidelines. The Guidelines require the consideration of potential losses of environmental characteristics or values resulting from direct, secondary, and cumulative impacts.

4.3.1.1 Direct and Secondary Effects of the 2020 Mine Plan

USACE provided its evaluation of the anticipated impacts from the discharge of dredged or fill material associated with the 2020 Mine Plan under the 404(b)(1) Guidelines (40 CFR Part 230) in its CWA Section 404 ROD (USACE 2020b). USACE concluded the 2020 Mine Plan did not comply with the CWA Section 404(b)(1) Guidelines because impacts to waters of the United States "from discharges of dredged or fill material at the mine site have been determined to cause significant degradation to the aquatic ecosystem" (USACE 2020b: Page B2-2). USACE (2020b) concluded that the discharge of dredged or fill material associated with the 2020 Mine Plan would result in significant adverse effects in all four effects categories in 40 CFR 230.10(c):

- Human health or welfare (40 CFR 230.10 (c)(1)).
- Life stages of aquatic life and other wildlife dependent on aquatic ecosystems (40 CFR 230.10 (c)(2)).
- Aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10 (c)(3)).
- Recreational, aesthetic, and economic values (40 CFR 230.10 (c)(4)).

USACE also concluded that "[t]he proposed avoidance, minimization, or compensatory mitigation measures would not reduce the impacts to aquatic resources from the proposed project to below a level of significant degradation" (USACE 2020b: Page B2-6).

EPA also considered relevant portions of the CWA Section 404(b)(1) Guidelines when evaluating the unacceptability of the potential direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, pursuant to EPA's CWA Section 404(c) regulations at 40 CFR 231.2(e). The following discussion provides an overview of EPA's evaluation.

4.3.1.1.1 Adverse Effects of Loss of Anadromous Fish Streams

As discussed in Section 4.2.1, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams. This loss represents approximately 13 percent of the anadromous waters in the NFK watershed.

The anadromous fish streams that the discharge of dredged or fill material associated with the 2020 Mine Plan would permanently eliminate are ecologically valuable, particularly for juvenile salmon (Section 3.2.4). Tributary NFK 1.190 is hydrologically connected with ponds and seasonally to permanently inundated wetlands that result from beaver activity (USFWS 2021).[83] These features

[83] Connection to such floodplain wetlands and ponds can greatly enhance the carrying capacity and productive potential of anadromous fish streams (Section 3).

provide excellent rearing habitat and important overwintering and flow velocity refugia for salmonids (Section 3.2.4) (Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Lang et al. 2006). The permanent loss of anadromous fish streams resulting from discharges of dredged or fill material associated with the 2020 Mine Plan would also result in the loss of salmon spawning habitat, which would, in turn, result in the loss of marine-derived nutrients transported upstream by those fishes. Given the naturally low nutrient concentrations in these streams, these inputs of marine-derived nutrients may be especially important in supporting primary and secondary production and, thus, food for juvenile salmonids in these and downstream habitats (Section 3.3.4). These streams also support production via inputs of leaf litter from deciduous shrubs and grasses in riparian areas (Meyer et al. 2007, Dekar et al. 2012), which help fuel the production of macroinvertebrates, a key food for salmonids (Table 3-3). Thus, the anadromous fish streams that the 2020 Mine Plan would eliminate, as well as similar habitats in the SFK, NFK, and UTC watersheds, play an important role in the life cycle of salmon.

These anadromous fish stream losses would adversely affect Coho and Chinook salmon populations uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). Such adaptation to local environmental conditions results in discrete, genetically distinct populations. This biocomplexity—operating across a continuum of integrated, nested spatial and temporal scales—depends on the abundance and diversity of aquatic habitats in the area and acts to stabilize overall salmon production and fishery resources (Section 3.3.3) (Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019). The substantial spatial and temporal extent of stream habitat losses resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan suggest that these losses would reduce the overall capacity and productivity of Coho and Chinook salmon in the entire NFK watershed.

The 8.5 miles (13.7 km) of anadromous fish streams that would be lost are mapped as upper perennial streams (PLP 2020b) and considered special aquatic sites with riffle/pool complexes (USACE 2020b). Under Subpart E of the Guidelines (40 CFR 230.41 and 230.45), special aquatic sites "are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region" (40 CFR 230.3 (m)). Loss of these 8.5 miles (13.7 km) of anadromous fish streams is significant due to effects on fishery areas in the NFK watershed. These special aquatic sites act as fish habitat and as sources of groundwater inputs, nutrients, and other subsidies important for salmon productivity (Section 3.2.4). Their loss would result in significant adverse effects on fishes (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in this watershed.

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles (13.7 km) of anadromous fish streams that would be eliminated by the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or

greater levels of loss of these anadromous fish streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the record, EPA has determined that eliminating approximately 8.5 miles (13.7 km) of anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); anadromous fish streams throughout these watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large amount of permanent loss of anadromous fish habitat; the degradation of additional downstream anadromous fish habitat due to the loss of ecological subsidies provided by the eliminated anadromous fish streams; and the resulting erosion of habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams

As discussed in Section 4.2.2, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of 91 miles (147 km) of additional streams that support anadromous fish streams in the SFK and NFK watersheds. The permanent loss of additional streams would result in reduced stream productivity in downstream reaches of the SFK and NFK due to the loss of physical, chemical, and biological inputs to downstream channels. Most of these permanently lost streams (77.0 miles [124 km]) are mapped as upper perennial streams (PLP 2020b) and considered special aquatic sites (USACE 2020b). The loss of upper perennial streams is likely to reduce water-holding capacity of the watershed by eliminating stream pools and meanders, thereby degrading downstream anadromous fish habitat through the reduced capacity for aeration and filtration (USACE 2020b).

The permanent loss of additional streams would adversely affect downstream habitat for salmon and other fish species (Section 3.2.4, Figures 4-3 through 4-5). These downstream waters are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in

the SFK and NFK watersheds (Figures 4-3 and 3-5 through 3-8). Permanent loss of these habitats would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK), as well as Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 91 miles (147 km) of additional streams would further erode habitat complexity and biocomplexity within these watersheds. The diversity of salmon habitats and associated salmon population diversity helps buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

These losses would result in significant adverse effects on fish and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These impacts are significant due to the effects on downstream anadromous fishery areas (Section 4.2.2) and the extensive loss of special aquatic sites, which are important sources of groundwater inputs, nutrients, and other subsidies crucial to salmon productivity (Section 3.2.4).

Other streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated by the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these additional streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that eliminating approximately 91 miles (147 km) of additional streams that support anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: headwater streams throughout the SFK, NFK, and UTC watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); that these three watersheds have similar amounts of total stream miles (relative to their watershed areas) (Table 3-6); that headwater streams across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of stream habitat and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of

downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater streams; and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

4.3.1.1.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

As discussed in Section 4.2.3, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters in the SFK and NFK watersheds.

Approximately 2,047 acres (8.3 km^2) of this permanently lost habitat are wetlands, a special aquatic site under the Guidelines. Wetlands and other waters that would be permanently lost play a critically important role in the life cycles of anadromous fishes in the SFK and NFK watersheds (Section 3.2.3) (PLP 2011: Appendix 15.1.D), given that "…all wetlands are important to the greater function and value of ecosystems and subsistence cultures they support" (USACE 2020a: Page 3.22-8). Moreover, wetlands and other waters affected by the 2020 Mine Plan "possess unique ecological characteristics of productivity, habitat, wildlife protection, and other important and easily disrupted values" (USACE 2020a: Page 3.22-1). The permanent removal of wetlands and other waters would destroy habitat, cause mortality of aquatic organisms, and reduce the collective functional capacity and value of wetlands and other waters across multiple watersheds. These permanent losses also would cause the displacement, injury, and/or mortality of species that rely on these aquatic environments for all or part of their life cycles (USACE 2020a: Section 4.22).

The discharge of dredged or fill material to these aquatic resources would reduce the biological productivity of wetland ecosystems by smothering, dewatering, permanently flooding, altering substrate elevation, or altering the periodicity of water movement (USACE 2020a: Section 4.22). The loss of such wetlands and other waters would eliminate structurally complex and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids.

In addition to the direct loss of habitat, loss of these wetlands and other waters would result in a total loss of their functions that support fish habitat, such as supplying nutrients and organic material and maintaining baseflows, in both abutting and downstream waters (Section 3.2.4). Downstream waters that would be degraded by the elimination of wetlands and other waters at the mine site are ecologically important and provide rearing and spawning habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8). This degradation of downstream anadromous fish streams would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 2,108 acres (8.5 km^2) of wetlands and other waters would further erode both habitat complexity and

biocomplexity within these watersheds. This diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

These losses would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These losses are significant due to their effects on downstream anadromous fishery areas and the extensive loss of special aquatic sites, which are key sources of groundwater inputs, nutrients, and other subsidies important for salmon productivity (Section 3.2).

Additional wetlands and other waters in the mine site area (Figure ES-5) are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres (8.5 km^2) of wetlands and other waters that would be eliminated by the 2020 Mine Plan at the mine site in the SFK and NFK watersheds (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5). Thus, the same or greater levels of loss of these additional wetlands and other waters from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that eliminating approximately 2,108 acres (8.5 km^2) of wetlands and other waters anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: headwater wetlands and other waters throughout the SFK, NFK, and UTC watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); that these three watersheds have similar amounts and types of wetlands (Table 3-2); that headwater wetlands and other waters across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater wetlands and other waters; and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams

As discussed in Section 4.2.4, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in streamflow alterations greater than 20 percent of average monthly streamflow from natural conditions in approximately 29 miles (46.7 km) of documented anadromous fish streams in the SFK and NFK watersheds. These changes in streamflow would alter the natural flow regimes of these systems (Poff et al. 1997) and could result in major changes in ecosystem structure and function (Richter et al. 2012), which could significantly reduce the extent and quality of anadromous fish habitats downstream of the mine site. Streamflow reductions would reduce habitat availability for salmon and other fishes, particularly during low-streamflow periods (West et al. 1992, Cunjak 1996); reduce macroinvertebrate production (Chadwick and Huryn 2007); and increase stream habitat fragmentation due to increased frequency and duration of stream drying. Increases in streamflow from natural conditions could result in increased scour and transport of gravels, affecting important salmon spawning areas (Brekken et al. 2022). Increased streamflows could also adversely affect distributions of water velocities favorable for various fish life stages (Piccolo et al. 2008, Donofrio et al. 2018).

As with the habitat losses and degradation described previously (Section 4.3.1.1) and in Sections 4.2.1 through 4.2.3, streamflow alterations would adversely affect downstream habitats for salmon and other fish species (Section 3.2.4, Figures 4-3 through 4-5). These downstream waters are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 4-3 and 3-5 through 3-8).

These streamflow changes would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), on life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These streamflow changes would degrade downstream anadromous fish streams, adversely affecting genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). The loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from streamflow alterations greater than 20 percent of average monthly streamflow from natural conditions in approximately 29 miles (46.7 km) of anadromous fish streams would further erode both habitat complexity and biocomplexity within these watersheds. The diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

Discharges of dredged or fill material anywhere at the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams downstream of the mine site that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9, Table 4-4). These anadromous fish streams support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section

3.3) (USACE 2020a: Section 3.24). Thus, the same or greater levels of streamflow changes in anadromous fish streams downstream of the mine site resulting from discharges of dredged or fill material associated with developing the Pebble deposit located anywhere in the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); anadromous fish streams throughout these watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large extent and magnitude of streamflow changes in anadromous fish streams; the corresponding degradation of anadromous fish streams, including spawning and rearing habitat, resulting from these streamflow changes (Section 4.2.4.5); and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.5 Conclusion

EPA has determined that direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in significant degradation under the CWA Section 404(b)(1) Guidelines. Additionally, EPA has determined that direct and secondary effects of the discharge of dredged or fill material associated with future proposals to construct and operate a mine at the Pebble deposit that would result in adverse effects that are the same, similar, or greater than the adverse effects of the 2020 Mine Plan would also result in significant degradation under the CWA Section 404(b)(1) Guidelines. These findings are based on the significantly adverse effects of the discharge of dredged or fill material on special aquatic sites; life stages of anadromous fishes; anadromous fish habitat; and aquatic ecosystem diversity, productivity, and stability under the CWA Section 404(b)(1) Guidelines.

4.3.1.2 Cumulative Effects of Mine Expansion

EPA recognizes that losses and degradation of these aquatic resources could be even more pronounced when the extensive cumulative impacts on the aquatic ecosystem that are expected to occur with successive stages of mine expansion are considered. The Guidelines describe as "fundamental" the "precept that dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern" (40 CFR 230.1(c)). The Guidelines require consideration of cumulative impacts in determining whether a project complies with the significant degradation prohibition of 40 CFR 230.10(c). The Guidelines state that "cumulative effects attributable to the discharge of dredged or fill material…should be predicted to the extent reasonable and practical." 40 CFR 230.11(g)(2). The Guidelines describe "cumulative effects" as:

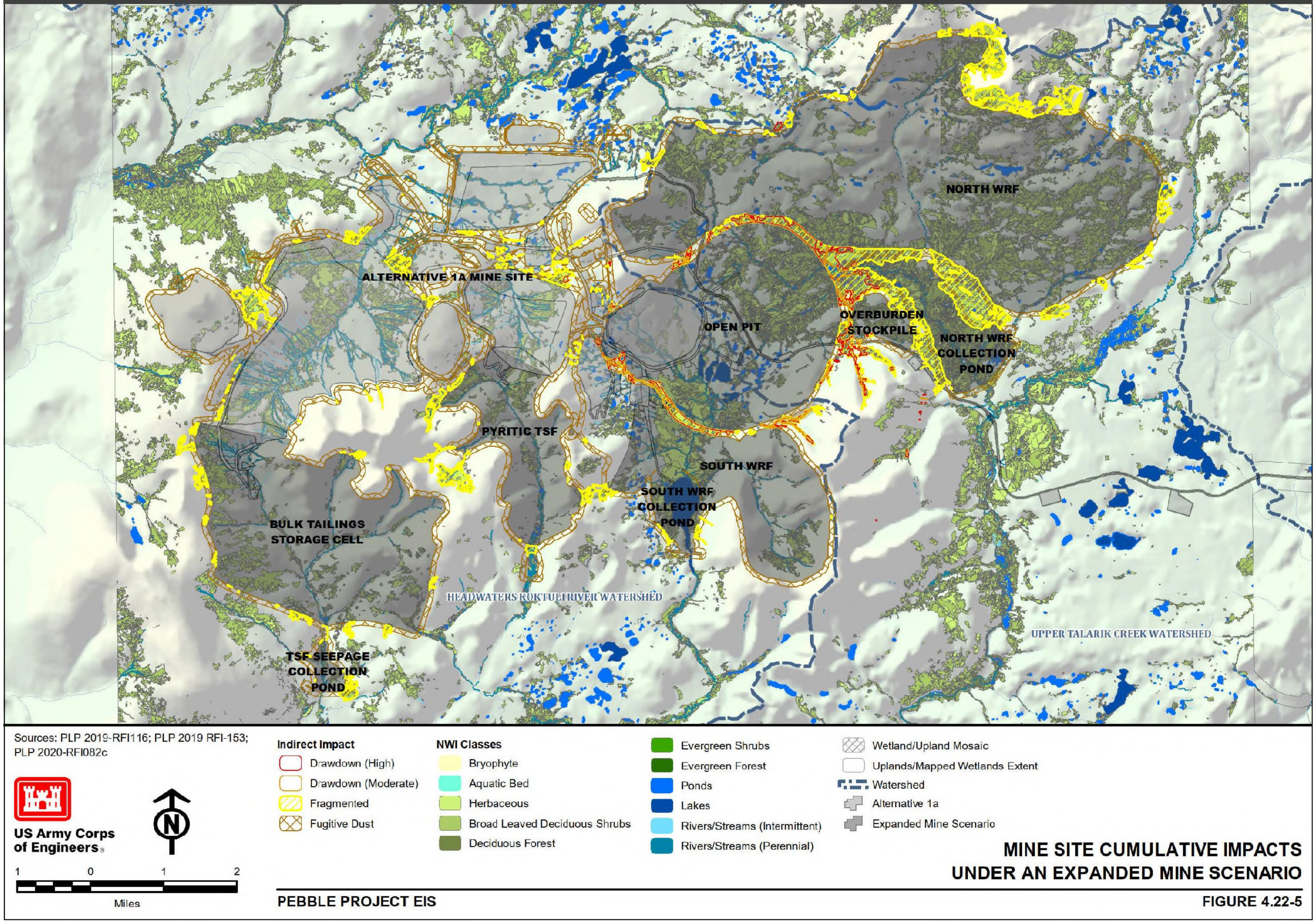
> The changes in an aquatic ecosystem that are attributable to the collective effect of a number of individual discharges of dredged or fill material. Although the impact of a particular discharge may constitute a minor change in itself, the cumulative effect of numerous such piecemeal changes can result in a major impairment of the water resources and interfere with the productivity and water quality of existing aquatic ecosystems. (40 CFR 230.11(g)(1))

USACE considered expansion of the 2020 Mine Plan (hereafter the Expanded Mine Scenario) a reasonably foreseeable future action and, therefore, evaluated the Expanded Mine Scenario for cumulative effects during its CWA Section 404 permitting process (Figure 4-12) (USACE 2020a: Section 4.1).[84] PLP's 2021 Preliminary Economic Assessment evaluated mine expansion as part of its projected production economics (Kalanchey et al. 2021), indicating that mine expansion continues to be reasonably foreseeable. The Expanded Mine Scenario is not part of the 2020 Mine Plan, has not otherwise been proposed, and would require additional and separate permitting (USACE 2020a: Section 4.1, PLP 2018c: RFI 062). Therefore, it is not a basis for this final determination.

EPA has concluded that the direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, as well as discharges that would result in effects similar or greater in nature and magnitude to the 2020 Mine Plan, would result in significant degradation under the CWA Section 404(b)(1) Guidelines. However, the Guidelines also require EPA to evaluate cumulative effects.

[84] For the purposes of the FEIS, "cumulative effects are interactive, synergistic, or additive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (RFFAs) regardless of what agency (federal or non-federal) or person undertakes those other actions (40 CFR 1508.7)" (USACE 2020a: Page 4.1-3).

Figure 4-12. Mine site cumulative impacts under the Expanded Mine Scenario. Figure 4.22-5 from the FEIS (USACE 2020a: Section 4.22)



Under the Expanded Mine Scenario, approximately 8.6 billion tons of ore would be mined (Kalanchey et al. 2021) over 58 years, with additional milling occurring over another 20 to 40 years, for a total of 78 to 98 years of additional activity at the mine site (USACE 2020a: Table 4.1-2). The Expanded Mine Scenario would use infrastructure included in the 2020 Mine Plan, such as the transportation facilities, power plant, and natural gas pipeline facilities, but would include a larger open pit; development of additional tailings storage, water storage, and waste rock storage facilities; and a concentrate pipeline and deepwater loading facility (USACE 2020a: Section 4.1).

The following subsections evaluate the cumulative effects on fishery areas associated with the mine site of the 2020 Mine Plan and the Expanded Mine Scenario. The following analysis does not consider associated facilities and transportation corridors.

4.3.1.2.1 Cumulative Effects of Loss of Anadromous Fish Streams

As discussed in Section 4.2.1, the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of streams in the NFK watershed with documented occurrence of anadromous fishes, specifically Coho and Chinook salmon. The Expanded Mine Scenario would eliminate an additional 35 miles (56.3 km) of streams in the SFK and UTC watersheds with documented occurrence of anadromous fishes (Figures 4-13 and 4-14) (USACE 2020a: Section 4.24). These additional stream losses represent 25.7 percent of anadromous fish streams across the SFK and UTC watersheds combined.[85] The Expanded Mine Scenario would also result in the complete loss of 544 acres (2.2 km^2) of lakes and ponds with documented anadromous fish use (Giefer and Graziano 2022), including the 150-acre (0.6-km^2) Frying Pan Lake in the SFK watershed. Frying Pan Lake, which would be inundated by the south collection pond, provides rearing habitat for Sockeye Salmon, Arctic Grayling, Northern Pike, whitefish, stickleback, and sculpin. Across the SFK, NFK, and UTC watersheds, the Expanded Mine Scenario would cause losses to documented Sockeye, Coho, Chinook, and Chum salmon habitats (Table 4-6) (USACE 2020a: Section 4.24).

The 2020 Mine Plan and the Expanded Mine Scenario would cumulatively eliminate nearly 33 miles (53.1 km) of documented Coho Salmon habitat, 13.7 miles (22 km) of documented Chinook Salmon habitat, and 7.8 miles (12.6 km) of documented Sockeye Salmon habitat across the SFK, NFK, and UTC watersheds. Each species would lose both spawning and rearing habitat (Table 4-6). The 2020 Mine Plan and the Expanded Mine Scenario would also cumulatively eliminate 1.6 miles (2.6 km) of Chum Salmon habitat across the three watersheds.

Eliminated and dewatered habitat likely would permanently lose the ability to support salmon. As discussed for the NFK watershed in Section 4.2.1, the substantial spatial and temporal extent of stream habitat losses under the Expanded Mine Scenario would also reduce the overall capacity and productivity of Coho, Chinook, and Sockeye salmon in the SFK and UTC watersheds. The genetic structure of these populations varies across fine spatial scales, and such extensive habitat losses within

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[85] The SFK watershed contains 60.0 miles of anadromous waters and the UTC watershed contains 76.2 miles of anadromous waters, based on AWC and PLP stream layers (USACE 2020a: Section 3.24).

these three watersheds would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and the UTC, as well as Coho and Chinook salmon populations in these watersheds that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). Coho Salmon may be particularly susceptible to extirpation through the loss of such populations (Olsen et al. 2003). Losses of small Chinook Salmon populations with diverse life histories have been reported in other regions (Lindley et al. 2009), with resulting impacts on overall population resilience (Healey 1991). Because Coho and Chinook salmon are the rarest of the Pacific salmon species, losses that eliminate unique local populations could result in the loss of significant amounts of overall genetic variability. The extensive habitat losses associated with the Expanded Mine Scenario would likely put such populations at risk.

The loss of 8.5 miles (13.7 km) of documented anadromous fish streams associated with the 2020 Mine Plan would already represent an unprecedented loss of documented anadromous fish streams in the context of the CWA Section 404 regulatory program in Alaska (Section 4.2.1). The loss of an additional 35 miles (56.3 km) of documented anadromous fish streams associated with the Expanded Mine Scenario would represent an extraordinary loss of anadromous fish habitat, which would be compounded by the complete loss of 544 acres (2.2 km^2) of lakes and ponds with documented anadromous fish use, including the destruction of the 150-acre (0.6-km^2) Frying Pan Lake.

Table 4-6. Anadromous stream habitat that would be permanently lost in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds under the 2020 Mine Plan plus the Expanded Mine Scenario.

Species	Life History / Habitat	Length of Stream (miles) by Watershed [a]			
		SFK	NFK	UTC	TOTAL [b]
Coho Salmon	Spawning	0.4	3.7	9.2	13.4
	Rearing	8.0	7.1	16.9	32.0
	Present	1.3	-	0.4	1.7
	Total Lost Habitat	8.0	7.1	17.8	32.8
Chinook Salmon	Spawning	-	-	3.6	3.6
	Rearing	2.7	2.3	6.6	12.4
	Present	-	1.4	2.7	3.3
	Total Lost Habitat	2.7	3.7	7.3	13.7
Sockeye Salmon	Spawning	-	-	4.8	4.8
	Rearing	1.6	-	3.7	5.3
	Present	-	-	1.1	1.1
	Total Lost Habitat	1.6	-	6.2	7.8
Chum Salmon	Spawning	-	-	0.5	0.5
	Present	1.2	-	-	1.2
	Total Lost Habitat	1.2	-	0.5	1.6

Notes:

a From the Anadromous Waters Catalog (Giefer and Graziano 2022).

b Salmon habitat types overlap and may be coincident, so these numbers cannot be added together.

Figure 4-13. Streams, rivers, and lakes with documented salmon use overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

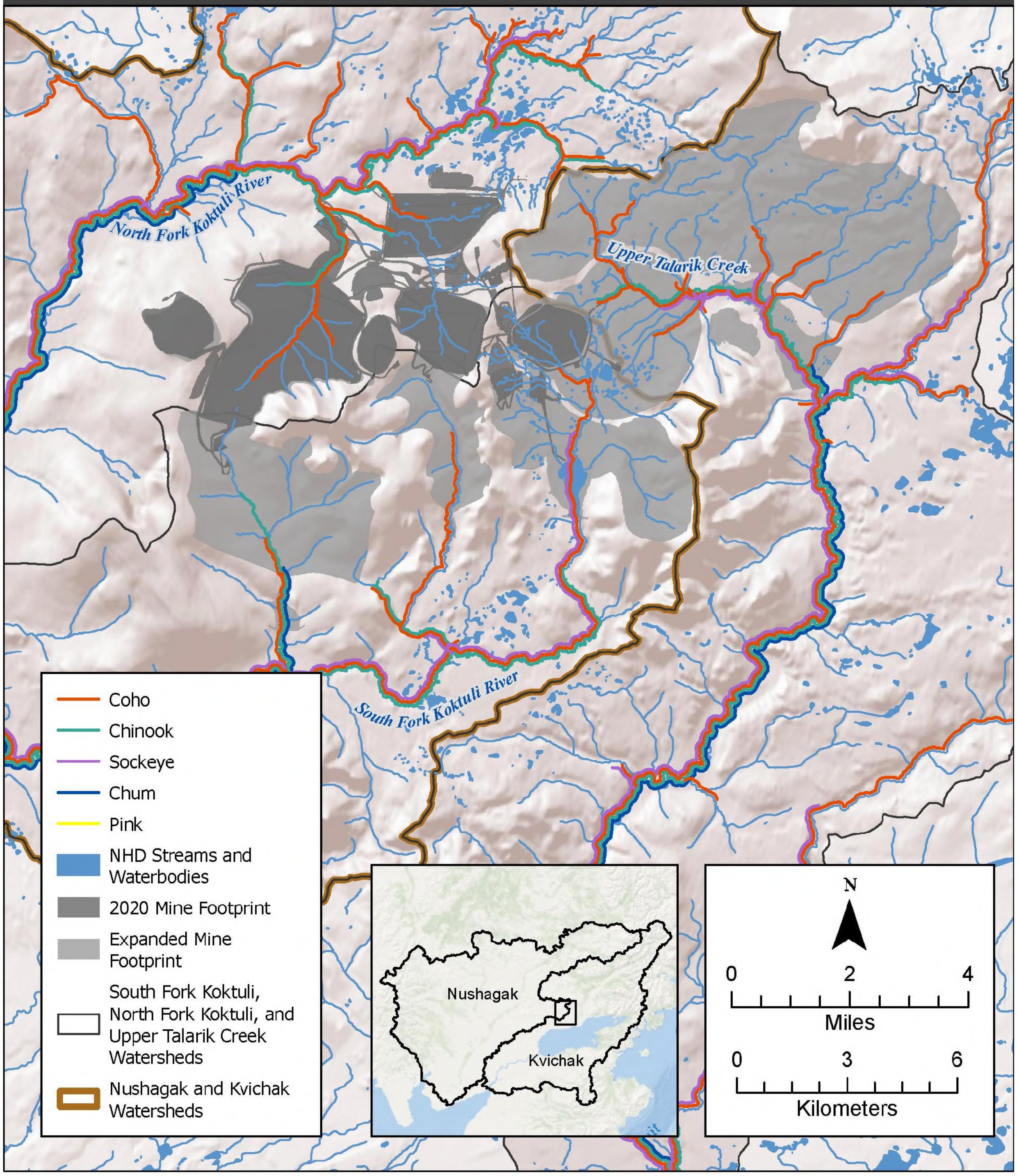
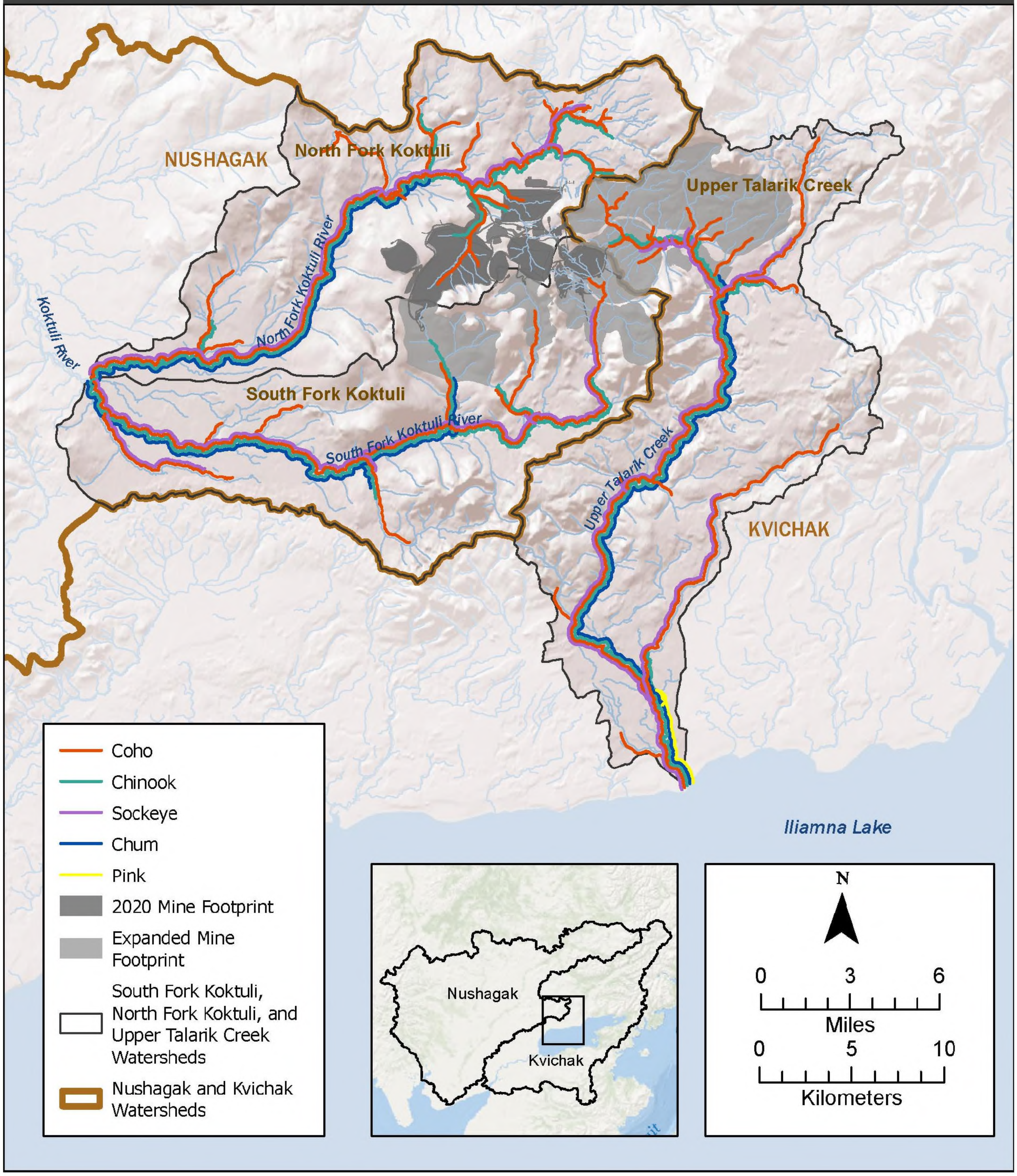


Figure 4-14. Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and Expanded Mine Scenario. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).



4.3.1.2.2 Cumulative Effects of Loss of Additional Streams that Support Anadromous Fish Streams

As discussed in Sections 4.2.1 and 4.2.2, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would eliminate 8.5 miles (13.7 km) of anadromous fish streams and 91 miles (147 km) of additional streams that support anadromous fish streams. The discharge of dredged or fill material for the Expanded Mine Scenario would eliminate 35 additional miles (56.3 km) of anadromous fish streams and result in the permanent loss of 295.5 miles (475.6 km) of additional streams that support downstream anadromous fish streams across the SFK and UTC watersheds, most of which would be perennial streams (USACE 2020a: Table 4.22-40). These permanent losses would substantially increase adverse impacts on anadromous fishes in the SFK and UTC watersheds (USACE 2020a: Section 4.22). Many of the eliminated streams likely contain anadromous fish habitat that has not yet been documented (Sections 3.2.4 and 4.2.1) but may be particularly valuable for juvenile salmonids. The unprecedented habitat losses in the SFK and UTC watersheds that would result from the Expanded Mine Scenario would exacerbate any unacceptable adverse effects on salmon and other fish populations caused by the 2020 Mine Plan.

Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimy Sculpin also would lose additional habitat under the Expanded Mine Scenario (Figures 4-15 through 4-18). The Expanded Mine Scenario would eliminate Rainbow Trout habitat beyond the NFK watershed and include losses in the UTC watershed (Figures 4-15 and 4-17). The Expanded Mine Scenario would eliminate Dolly Varden habitat beyond the NFK watershed and include losses in the SFK and UTC watersheds (Figures 4-15 and 4-17). The Expanded Mine Scenario would increase habitat losses for Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimy Sculpin in the SFK watershed. The Expanded Mine Scenario would also eliminate habitat for Arctic Grayling, Ninespine Stickleback, and Slimy Sculpin in the UTC watershed (Figures 4-15 through 4-18). In addition to direct habitat losses, increased loss of stream habitat under the Expanded Mine Scenario would substantially alter streamflows and other ecological subsidies provided to downstream fish habitats in the SFK and UTC watersheds (Figures 4-14 and 4-18). Associated reductions in streamflow to downstream fishery areas would likely reduce the extent and frequency of stream connectivity to off-channel habitats, as well as alter the thermal regimes of downstream habitats (Section 4.2.4). These habitats also would no longer support or export macroinvertebrates, an important food source for juvenile salmon and other fish species.

Figure 4-15. Reported Arctic Grayling, Rainbow Trout, and Dolly Varden occurrence overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).